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THE UNIVERSE AS A WHOLE[1]

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> In Nature's infinite book of secrecy
> A little I can read
>
> —*Antony and Cleopatra*

Thinking Cosmically

Most men to-day are engrossed in some one particular profession or occupation, that may involve monotonous drudgery, or may require special skill, technical knowledge, long experience and, more rarely, profound thought.

But it is doubtful if any group of men, except perhaps a few philosophers, is engaged in fitting together the jig-saw or patchwork puzzle of the multitudinous discoveries and theories of all our diverse branches of knowledge. Thought is thus divided into water-tight compartments, between which the communications are blocked.

[1] Presidential address before the Royal Society of Canada, given on May 20, 1930.

Indeed, the further question arises whether the different parts of the puzzle will, in the present state of our knowledge, fit together at all; whether the gaps and misfits are not too wide and too great to permit of the undertaking. It is pertinent to remark that many of the great advances to-day are made by those who are fortunate and able enough to be expert in two subjects, for example, in physics and in physiology, or in mathematics and physics, or in physics and chemistry, or in physics and philosophy. Borderlands are prolific.

There is a further difficulty in finding a man with a sufficiently catholic taste to consider all the realms of knowledge as a unity. Who indeed is equipped mentally for such a giant's task? Who can say nowadays with Bacon that he "takes all knowledge for his province"?

Certainly not the present writer! The fitness rather rests with the audience, for the Royal Society of

Canada consists of men carefully selected for their achievements, as authors, poets, historians, statesmen and as savants of every branch of natural science, the very list of which it would be tedious to recite. These men, too, belong to at least two types of Western European civilization, crudely summarized as English and French, including our inheritance from Greece and from Rome.

Perhaps then we are justified in following the advice of Fitzgerald, "to think cosmically," and to contemplate the universe as a whole.

The Framework of the Macrocosm

We find scattered through a vast region, nebulae, stars, planets, moons, comets, meteors, dust, gases and their radiations, with the main masses, the stars, far apart compared with their size, dominated by a mutual attraction, all in motion with respect to each other. There is there no such thing as rest. All these stars move with velocities ranging from a few miles a second to a few hundred miles a second. There is no suggestion of a very high gravitational potential; in simpler words, we see no evidence of an infinite, but rather of a large finite amount of matter in the universe.

Between these bodies there exists, or our intelligence infers from experience, a space approximately Euclidean, where the three angles of a triangle certainly do equal two right angles very nearly indeed.

This space has remarkable physical properties inasmuch as waves of a common nature pass swiftly in all directions freely, without interfering with one another's progress, differing, however, in wave-length, and all having the well-known high speed of light. This velocity appears to be one of the great constants of nature, which may be regarded not as relative, but as independent of the velocity of the source and of the speed of the observer. Space, then, is the region or vehicle of radiant energy. Since we know, or conjecture, that all matter is but one form of energy we can estimate energy in terms of mass, and we may even quote the price of radiant energy in pounds in place of kilowatt-hours, and calculate the quantity received by the earth from the sun. The price is high and the quantity large. The earth receives from the sun about 160 tons of sunlight a day, to a value of 500 million dollars a pound, so that our power bill amounts to 150 million million dollars a day, reckoned on the basis at which we have to buy our electricity in Montreal. This power bill is of course never presented, and our power-house, the sun, has been running effectively and regularly for at least ten thousand million years, and is likely to run, bar unforeseen accidents, for as many years at least in the future. We will postpone for the present the question of its closing-down!

This great space through which radiant energy passes may be regarded as empty or, inasmuch as it has the wonderful property of transmitting power, we may consider it as a physical entity, deem it worthy of a name and continue to call it ether, remembering always that in practice we give names to those things which have observable properties or distinguishable attributes. Apparently we must entirely divest our minds of all material ideas when we speak of the ether, but this will trouble us less and less as we continue to strip matter itself more and more of material attributes, and focus our attention on the less palpable manifestation of energy. Not that it is suggested that the word spiritual would at all help us in our idea of ether, nor can we find any warrant in fact, so far as present knowledge and experience seem to go, that the ether is the seat of psychic forces of a non-physical character. Any confusion between these ideas is at present the reverse of helpful, but even if the properties of the ether are one thing, and the properties of matter another, yet the linkage between them is so intimate that it may be that matter is merely a local singularity or peculiar structure of ether, as Sir Joseph Larmor and others have suggested.

At present it is still convenient to think of the universe as consisting, physically, of matter and of ether, or if you please, of two different forms of energy, matter and radiation alike passing through space.

Space

If, as is the fashion to-day, we are relativists, we can believe that our space is finite but unbounded, and we are at liberty to agree with Silberstein that no distance greater than nine million light-years is measurable in our universe. This leaves ample room for most of us, but it may be that some astronomers will feel themselves sadly cramped in so narrow a space, and indeed they now speak of distance exceeding a hundred million light-years.

To some degree it exalts the importance of each individual to realize that each one is the center of his own universe wherever he be, and however fast he may move. Every man has his own ether, just as every man has his own rainbow. All the signals of nature which we receive by our senses and interpret by our minds are of course different for each individual.

Speculations as to space and ether have a powerful fascination, but our actual knowledge is summed up by such ideas as Faraday's lines and fields of force, and more precisely by Maxwell's equations for elec-

tromagnetic fields. It was the effort to verify the truth of these equations which led Hertz to discover wireless (or radio) waves which enter to-day so largely into human life and experience.

The Microcosm

As we find that the universe may be bounded in its size as regards greatness, so we may ask whether there is any limit in the other direction, whether there is any limit as to the possible smallness of an entity, and although the time is not yet ripe to speak definitely on this question, yet we shall see shortly that there may indeed be some limitation of the kind which I have suggested.

First let us, however, return to our suns, planets and moons, and realize that they are all made out of the same stuff, and of the very same elements with which we are familiar on this earth. This common material suggests, does it not, a very thorough mixing together in the past? The stars, each one of them, go through a regular prolonged stage of evolution, so that a glance at a star's spectrum, taken with telescope and prism, immediately informs the trained observer whether that star is in glorious growth, comfortable middle age or finally in the autumn of life or senile decay. Those stars which have reached their winter may be invisible to us, dark stars whose only chance, and that exceedingly remote, of a continuance of activity is a collision with a traveling neighbor.

The material of the universe everywhere consists of ninety-two elements, and it is now known that there remain only two or three to be discovered, unless there are some heavier than uranium. These elements are the bricks of which the great edifice is composed throughout. They exist rather permanently as atoms, except in one great group of radioactive atoms, which spontaneously disrupt and become new atoms. Some of the elemental atoms have also been deliberately broken up, by careful design, as when Rutherford knocked hydrogen nuclei out of nitrogen, using alpha particles of radium as his Big Bertha or Roaring Megs. This control of atoms and their behavior tells a very different story from the nineteenth century idea of hard, elastic, everlasting and indivisible atoms.

Atoms are wont to link together by bonds invisible and unknown (probably electromagnetic) and to combine into molecules, sometimes simple, and at other times, as in vegetables and animals, of appalling complexity. The simplest plant is a complex and marvelous chemical factory, which can also give birth to other similar factories! In the simpler cases it would at first appear probable that we could say—a molecule of water consists of two atoms of hydrogen and one atom of oxygen. We know the properties of both these constituent gases, therefore we can deduce the properties of the water molecule, and can foretell all the chemical and physical behavior of ice, water and steam. I need hardly tell you how immensely short we fall of this achievement at present, yet it is a perfectly reasonable goal towards which to strive. The matter is of such profound philosophical importance that it may be wise to dwell on it longer. The behavior of the hydrogen atom is well known, but is it possible to deduce the properties of the hydrogen molecule, which is two atoms in close partnership? Here we have the most direct and simple problem of physico-chemistry, and yet it turns out to be terribly complex; indeed men are spending a large part of their lives on such apparently simple problems. It seems that from two simple entities there is created, or there evolves, a quite new and different complex or entity. Surely there is some satisfaction to the biologists in this situation! We may use the dubious phrase "creative evolution," but the wonder is not that new forms arise; the larger mystery is how species are preserved, and how it is possible for offspring remotely to resemble their parents and ancestors!

To return to the molecules—after formation they are usually in a dynamic state, with their atoms oscillating to and fro, or revolving around one another, or both. The molecules may at the same time be rushing about with the velocity of bullets as in a gas, frequently colliding and rebounding, or they may jostle one another about in that crowded state we call a liquid, of which motion there is good evidence in the Brownian movement.

Yet again the molecules may, like men in a well-drilled army, fall into rank after rank of orderly arrangement so that there is a crystal, coherent, solid! The study of crystals has occupied, and is occupying, the lives of many of the ablest men in the world. In the great harmony of crystal arrangement there is to the human mind a satisfaction found elsewhere perhaps only in mathematics and in music.

Atoms and Electrons

Hunting further in the microcosm we find physicists restless in the pursuit of the interior constitution of the atom. The genius of J. J. Thomson, Rutherford, Moseley, Bohr and others has drawn back the veil even in the lifetime of most of us, so that we find the bulk of the weight, mass or substance of an atom concentrated at the very nucleus or inner citadel, as a positive charge of electricity, this nucleus being small indeed compared with the whole atom. Around the nucleus we had a most satisfying picture or model of a swarm of electrons from one to ninety-two,

according to the number of the atom, going swiftly around in elliptic orbits somewhat as planets go around our sun, with the most disconcerting added behavior that these electrons could leap from one orbit to another according to well-conceived plan or rule, totally at variance with all our previous knowledge of how well-ordered bodies should behave. Hence the great quantum theories which so greatly perturb old-fashioned physicists, who have to face a revolution in their electrodynamic conceptions when they endeavor to apply them to the constituent parts of an atom. It is curious to note that the principle of relativity has greatly attracted the attention of the thinking public, while the far greater *bouleversement* of quantum mechanics has hardly yet received attention.

At any rate, in place of the ninety-two elements in the universe, we enthrone two and only two physical entities—protons and electrons—together with the radiations or electromagnetic waves which pass through space between them, for every atom is both a wireless broadcasting station and also a wireless receiving station between which energy exchanges take place only in definite "lumps," each lump, bundle or quantum strictly proportional to the frequency transmitted; in other words, the illusive action is strictly atomic; or the ultimate "energy-time" is indivisible, a real atom. This sublimely simple electronic theory of the universe is now the fundamental common stock of all physicists, and provides sufficient and reasonable foundation for all purely physical phenomena. Yet it has been realized that the picture is too crude, and that there is either a limit to our perception or a limit set by nature herself, so that authorities like Bohr, Heisenberg, Schrödinger and Dirac assure us that we must abandon all models, all diagrams, all our large-scale experience, whether suns, planets or billiard balls, and admit that the microcosm does *not* resemble the macrocosm: that of the electron we can never say, Lo! here it is! It has gone before we say it. To mention its speed is to lose its position, or to indicate its place is to confound its speed. This is profoundly disconcerting to those, who, like the writer, have been brought up to revel in models and lines of force and diagrams. Only mathematical equations, complicated enough, expressing wave motions, can now describe the behavior of atoms and electrons. Only the probability can be calculated of the place or motion of individual electrons. The physicist stands as actuary calculating the statistical behavior of a crowded and confused entity. That there will be a reaction to these tendencies is most probable, perhaps led by plain-thinking Anglo-Saxons; but whether the reaction will be the more successful is quite another question. *Magna est veritas, praevalebit!*

Our satisfaction in the present physical outlook is further modified by two points. In the first place, we can not pretend to give any explanation of electricity or of electrical energy in terms of anything more simple or fundamental, so that there is still no bottom found to the deep well of truth. In the second place, when we are confronted with questions as to the origin and the enduring qualities of things we have no physical suggestion whatever, not the vaguest guess, to offer in reply. Two of the most important movements of to-day are these. The insistence that science must confine its attention to observable and measurable quantities, thus sharply separating physics from speculative metaphysics; and secondly the growing possibility that the search for the ultimate nature of substance is futile and, like perpetual motion machines, may be safely abandoned. Effort is concentrated on the structure, on the form, arrangement and resulting habits or behavior of things. Thus the appeal to models is passing away, and the trust in mathematical symbols, equations and deductions is growing stronger.

Personally I flatly rebel against all trammels and I advocate complete freedom in attacking all problems by any means available. When the key is lost, smash the lock and force the cupboard; and when the front stairs are blocked, try the back or a ladder outside. The work of many Anglo-Saxons has been of this direct and practical character, and it has proved singularly fruitful in face of difficulties. If Maxwell had been restrained, would his imaginative genius have produced his great treatise on electricity?

AGE OF THE UNIVERSE

There is clearly stamped on the universe a great but not an infinite antiquity. By all the known laws of physics the universe is a going concern, perhaps in middle age, which has not gone on forever and will not continue forever.

Two great tenets of science have been (1) the conservation of mass, the foundation of chemistry, and (2) the conservation of energy, the foundation of physics. It now appears probable, from the physics of the stars, that matter can cease to exist as such and give birth to a precisely equivalent amount of radiant energy. There is diligent search for the reciprocal transformation, wher y the continual outpourings of light and heat, radiating from all the stars and spreading into empty space, may again collect and reorganize into electrons, protons and atoms. No such changes are at present discern le.

Newton's queries in his "Optics" had some premonition of such energy changes:

> Are not gross Bodies and Light convertible into one another, and may not Bodies receive much of their Activity from the Particles of Light which enter into their composition?

The changes of Bodies into Light and Light into Bodies is very comformable to the Course of Nature which seems delighted with Transmutation.

To-day this statement simply becomes, following Einstein,

$$E = Mc^2$$

where E is the energy, M is the mass and c the great constant, the velocity of light. By this equation we can express mass as energy, grams as ergs, or pounds as foot-pounds, or the converse.

It is not, however, the question of the annihilation of matter or the elimination of energy with which we are now concerned; rather it is the well-known fact that energy tends to become degraded or unavailable. All power machines and all life depend ultimately upon a source of heat relative to a cooler environment. Old age brings on that feebleness of energy which is no longer available when all has reached a dead level. There can not be water-power when the land is all at sea-level. Nor can you grind corn with water that has passed the mill! Unless indeed as now the beneficent rays of the sun, falling on the wide bosom of land and sea, lift again that water into the moving clouds to send a gracious rain on our inheritance. Many attempts have been made to remove this rather dismal picture of a worn-out universe from our imagination. Heat-death, it may be called.

The physical universe is proceeding, not to ruin, but to a dull uniformity. The energy will still be conserved, but it is becoming less and less available either for doing work or for sustaining life.

Had not Newton some conception of this question of the degradation of energy when he wrote the thirtieth query in his "Optics"?—"Motion is much more apt to be lost than to be got."

Jeans states that

Everything points with overwhelming force to a definite event, or series of events, of creation at some time or times, not infinitely remote. . . . The universe can not have originated by chance out of its present ingredients, and neither can it always have been the same as now. For in either of these events no atoms would be left save such as are incapable of dissolving into radiation; there would be neither sunlight nor starlight, but only a cool glow of radiation uniformly diffused through space. This is, indeed, so far as present-day science can see, the final end towards which all creation moves, and at which it must at long last arrive.

Let us admit that "as far as present-day science can see" at the long last there are to remain some dead stars, some inert atoms and "the cool glow of radiation uniformly diffused through space," which must, of course, be perpetual, everlasting, devoid of change. But does anybody seriously believe that?

Jeans himself admits that everything points with overwhelming force to a definite event, or series of events, of *creation* at some time or times, not infinitely remote. Where there is creation, then there is purpose. Where there has once been purpose, there may be continuation of purpose, or a recurrence of purpose. So also if there was once creation there may be a continuance of creation or a fresh creation. Eliminate purpose and there is no creation and no beginning to the physical universe. At what stage then can purpose be eliminated? This question is not now popular, and the word "teleology," meaning purpose, or direction towards an end in view, is largely taboo in science to-day. But why?

This tendency of energy towards decadence was never more exquisitely stated than in the "Tempest," when Prospero, after showing his vision, exclaims:

These our actors,
As I foretold you, were all spirits, and
Are melted into air, into thin air:
And, like the baseless fabric of this vision,
The cloud-capp'd towers, the gorgeous palaces,
The solemn temples, the great globe itself,
Yea, all which it inherits, shall dissolve,
And, like this insubstantial pageant faded,
Leave not a rack behind. We are such stuff
As dreams are made on; and our little life
Is rounded with a sleep.

After which he begs us—

Bear with my weakness; my old brain is troubled.

Well! Troy, Babylon, Carthage, have gone and we do not greatly lament them, and shall our turn not come? "Heraclitus is dead; and he was a better man than thou!"

Where we now are there was a sheet of ice perhaps four thousand feet thick. The ice will come again, and perchange go again, but ultimately it will remain.

And yet the full tide of pessimism has not been fathomed, for consider the words of Bertrand Russell in "Mysticism and Logic":

That man is the product of causes which had no prevision of the end they were achieving; that his origin, his growth, his hopes and fears, his loves and his beliefs are but the outcome of accidental collocations of atoms; that no fire, no heroism, no intensity of thought and feeling can preserve an individual life beyond the grave; that all the labours of all the ages, all the devotion, all the inspiration, all the noonday brightness of human genius are destined to extinction in the vast death of the solar system, and that the whole temple of man's achievement must inevitably be buried beneath the debris of a universe in ruins—all these things, if not quite beyond dispute, are yet so nearly certain that no philosophy which rejects them can hope to stand.

Here indeed we have the very quintessence of ultra-pessimism. But as the man who tried to be a philosopher said to Dr. Johnson, "Cheerfulness will keep breaking through." Nobody need believe these things unless he likes; indeed we do not really know all this.

For another great philosopher, Whitehead, writes, "The fact of the religious vision and its history of persistent expansion is our one ground of optimism. Apart from it, human life is a flash of occasional enjoyment, lighting up a mass of pain and misery, a bagatelle of transient experience." But even this optimism has a decidedly neutral tint. The fact is that we are in a period of great flux and change, still under the shadow of the great war and its gloomy aftermath. It is the glory, the privilege and the responsibility of the present generations that they have immense new problems to solve. If we conform to the narrow limitations of a purely mechanical outlook, we shall never see the wood for the trees, and we shall reap as we sow. If the greater qualities are brought into play, then there may be success! What are these qualities? Dean Inge has compactly described them—"truthfulness, courage, justice and fair play, abhorrence of meanness and crooked dealing, and respect for all human beings as such."

The tendencies that we observe in a long period of time are really ephemeral; a fly, living but for a day, can not hope to detect the motion of the planet Neptune. It was a fly too in the fable, that, seated on a chariot wheel, exclaimed, "See! what a dust do I stir!"

Perhaps we should never say that at some distant date the universe was created; rather let us say, the universe is now being created, and insist that at all times such a statement has been true. Shall we add with Walt Whitman that the universe was never more perfect than it is now, and conclude with Marcus Aurelius, "Could he say of Athens, Thou lovely city of Cecrops, and shalt thou not say of the world, Thou lovely city of God?"

TIME

Like other entities time is a matter of experience. To the mathematician time is readily reversible, but in experience the past and the future are sharply distinguished. I can actually go to California and back, but not to last week and back, except in memory.

Yet if I go to California I must expend time to cover space; nor is my journey direct, but to right or left, and up and down, added to the actual distance, so that we have three degrees or types of space linked to one of time, and Minkowski brilliantly showed us how inevitably these were united in the four-fold union of space-time.

It has always seemed to me that even in this four-dimensional union something is still lacking. In order to go to California I must have money, an important fifth degree of freedom. It is well known, however, that money is merely the opportunity to acquire what we think that we need, and on a journey money buys energy, so requisite for the traveler's life and movement, and no less essential to the army of workers who to-day assist him on his journey whether by direct or mechanical means. A bird can obtain its energy directly from food, and requires no money for sustenance, clothes or transportation.

The fifth degree of freedom is, therefore, energy, and a large part of it we derive from breathing air, the only thing still free to all, without taxation or payment.

It is a remarkable fact that, in physics, energy has an intimate relation with time, and also with frequency; so that it is a particular fad of the author to endeavor to ascertain to what extent we can substitute the frequency of waves for the perhaps less tangible, but more familiar, concept of energy. This is scarcely the place to enlarge on this idea; and it must suffice to point out that, as Einstein explained gravitation on a geometrical basis, so it may be possible to consider energy more fully as an aspect of frequency, possibly arriving at a comprehensive wave theory of the universe.

Eddington in his "Nature of the Physical Universe" sets forth a fascinating picture of the inevitable unidirectional progress of time, as almost embedded in nature. The second law of thermodynamics, the running down of the universe as if it were a clock, with the gradual degradation and unavailability of energy, are picturesquely referred to as "time's arrow." The fact that certain processes in nature can not be reversed may lead to the result that time can not be reversed. To an intelligence higher than our own, time past, present and future might conceivably have a oneness quite foreign to our experience, but not perhaps beyond the imagination of a mathematician.

LIFE

So far we have considered matter apart from life. All the difficulties hitherto encountered become intensified by a new factor, which can not even be defined, when we consider living things. To suggest that life is merely mechanism is to confuse two terms with quite different meanings. Machines are contrived from without, but living things are organized from within, and we can not definitely demonstrate either conscious purpose or intelligent directing mind. Yet we do see the most marvelous coordination of the whole, due to the cooperation of the constituent parts. I am speaking of such things as trees and bees, and of many happenings within our own bodies. Were

these events left to our conscious and intelligent selves, then our lives would not be prolonged for a minute. We have not intelligence enough to manage even a minute part of our bodies for a small fraction of a second. For example, who of us all would dare to assume complete responsibility for the output of new blood corpuscles, or for the necessary continual repairs, say, to his eye?

If a man breaks a leg, nature repairs it for him. Who and what is this nature?

> Nature is neither kernel nor husk—she is everything at once.
>
> —*Goethe*

> Nature is at once a *science* which never leaves off deducing effects from causes and an *art* which without end exercises itself in new inventions.
>
> —*Lachelier*

> Nature is now no more—even to the scientific thinker —a mechanical contrivance like a complicated and highly ingenious machine. . . . Nature is—what it always has been to the common sense view—a texture in which the mechanical warp is shot through everywhere by the spiritual woof.
>
> —*Merz, modified from William Jones*

That living creatures are constructed of matter no one will for a moment dispute; that there are, in life, transferences of energy which fully obey the laws of physics and chemistry no one will deny, but to insist that these laws or theories, as we now know them or even as they may develop, impose a necessary limitation to our conception of life, or to regard them even remotely as causation, is a step quite unwarrantable. What then do we need to add? There is nothing to suggest! But because no answer is at present forthcoming we can not assume that an answer is forever impossible. No doubt one important factor is the organization as a whole, which is not merely a sum of its parts.

The pretty quarrel between mechanists and vitalists and neovitalists is likely to continue with varied success on shifting battlefields. We can hardly be expected to settle the question this evening.

Let us, however, note three conclusions: Every form of matter comes from matter; every form of energy comes from energy; every living cell comes from a living cell.

The first two statements have already been shown to blend into one, so that matter may now be regarded as merely one form of energy. Nor need we doubt that life is also a form or manifestation of energy. What, then, is energy? Every schoolboy is ready with the answer, "Energy is the capacity for doing work." A mere translation! However, many schoolboys are capable of the more important step of actually measuring such work. Yet the definition reminds us of the gibe of Ruskin. "Why are the leaves of a tree green?" "Because they contain chlorophyll." "Then," he says, "you tell me that leaves are green because they contain green-leaf!" But truly, the situation is not as bad as it seems, inasmuch as man has now acquired so full a knowledge of what we may term the "habits of energy" that he can not only trace the interchanges of energy in nature, but he can also direct energy to his advantage and benefit. There is the enormous further achievement that energy is measurable by man and this is the first necessity for control. Hence there arise the multitudinous applications of mechanics and electricity which have invaded our lives in abundance and with such complexity, all depending upon known principles of physics. Indeed, we are rather intoxicated by these successes which leave the impression of far greater wisdom than perhaps we can justly claim, and we are apt to regard progress in mechanical and electrical contrivances as progress in civilization, which, of course, depends not only on material, but on intellectual, moral and spiritual values and qualifications.

ORIGIN OF LIFE

As to the origin of life, it remains, like the origin of matter, quite obscure. But the problem is not in the same category. To account for the origin of matter we have to regard it as arising from nothing; we have to consider energy proceeding from no energy, something quite outside our experience, and so unthinkable. It is not so when we consider the origin of life, where the material and the energy are both available. Hence there is speculation in the direction of highly complex molecules originating, step by step, from the simpler available molecules by the action of the ultra-violet rays of the sun. Some first fruits of chemical experiments in that direction have appeared. To be precise, sunlight has coaxed, so to speak, water and carbon dioxide to form formaldehyde. That step is truly a long way from the living cell. Rather vague terms are used to explain the further stages, such as surface tension and osmotic pressure, but my biological friends state that no "simple" cell is known to them. There is very great complexity in the simplest forms of life. Moreover, an eminent physiologist (Adrian) has stated:

> The nervous system is a mass of living cells which has the extraordinary property of appearing to influence, and to be influenced by, the mind. . . . It is a material system somehow responsible for such non-material things as emotions and thoughts. These are in a category outside the range of mechanical explanation, and for this reason the working of the nervous system will never be fully explainable in terms of physics and chemistry.

Again, Lord Balfour, writing as a philosopher, states, "No man can either perceive or imagine the mode in which physiological changes give birth to psychical experiences."

Most of us will concur with these verdicts, but we must remember that there is a more daring school who repudiate these limitations, due, they say, to the present imperfect state of our knowledge.

If the organic rose from the inorganic, then there is the first stage of the stupendous developments of life, both in number and in type, which surround us on this wonderful planet. Certainly a single fiat of creation has, in most thinking minds, given way to the more glorious conception of the perpetual creation which surrounds us. To-day is created anew from yesterday. One second gives birth to a fresh and different succeeding second, and yet between them an enduring linkage occurs. While it is not difficult to coin phrases to describe and summarize this remarkable development, and perhaps the term creative evolution is the most helpful, yet we must use it merely as a label or description, and avoid the common blunder of confusing a name with a cause.

Somehow in the human frame the front legs have become arms, and the front feet, hands, while one digit on each hand has become a thumb. The young child crawling on all fours as a little quadruped painfully and with repeated practice raises himself on his hind legs and learns to walk. Only the anatomists and physiologists are fully aware of the intricate coordinations which these efforts, conscious and unconscious, demand on the brain, nerve and muscle. Does the young child herein repeat a part of the story of the race, of its ancestry? Indeed, it has been stated that "every bone and every muscle of man's body have undergone profound structural alterations to fit him to his orthograd posture."

Certainly repeated struggles and strivings are necessary for the preservation and development of every form of life, while disuse leads towards annihilation; but these sage reflections, which may briefly summarize an observable process, leave all the most fundamental questions unanswered.

The highest development perceived or known in the universe is found in the intelligence and soul of man. Just as the properties of space have given rise to the rather vague term, ether, as a term indicative of properties and happenings, so such words as mind and soul are convenient summaries for unquestionable attributes.

It is somewhat strange to think that if the whole human species were submerged in Lake Ontario the water would rise but a few inches, and doubtless the universe as a whole would go forward but slightly affected, and dynamically and materially unimpaired. There was such a time, perhaps less than ten thousand million years ago, when there was no life on this earth; there will be such a time perhaps a hundred thousand million years hence when life on the earth will have passed away. Few will dispute the calculation of Harold Jeffreys that in a million million years all the waters of the ocean will have frozen to the very bottom and all the land be covered with ice and snow. Go, however, into one of our great libraries and you will find that the majority of books deal with man and his history and achievements. Why this importance attached to man? Do we flatter ourselves? Can we be just super-monkeys traveling on a speck of a planet going round a commonplace sun?

This pessimistic suggestion stands in sharp and dark contrast with the idea that this world is a training ground for immortal spirits. The view of Professor A. N. Whitehead may prevail that though the universe is physically descending, yet it is spiritually ascending.

Physical Fields

In order to further an attempt to approach a general view of the universe it is desirable to return for a while to the ideas of Faraday and to contemplate what he termed fields of force, or, as we might say, domains of energy. In a notable sentence he writes:

> The view now stated of the constitution of matter would seem to involve necessarily the conclusion that matter fills all space, or, at least, all space to which gravitation extends (including the sun and its system); for gravitation is a property of matter dependent on a certain force, and it is this force which constitutes the matter. In that view, matter is not merely mutually penetrable, but each atom extends, so to say, throughout the whole of the solar system, yet always retaining its own center of force.

It is probable that Einstein could modify this statement so as to cover his theory of gravitation where a geometrical field is caused or modified throughout space, so as to account for the motion of the heavenly bodies without the "forces" of which Newton conceived and about which Faraday was writing.

The word "field" has a wide use in the English language, such as hayfield, battlefield and so forth. In every case it denotes an area or region of events or happenings. Its introduction into physics has been fruitful. Near the earth, matter falls towards the earth in straight lines or curves and we can explore the laws or habits of material objects in this gravitational field. Newton extended this localized field from the earth outwards to the moon and throughout the

solar system. To-day the field is extended to include the motion of the double stars.

Around the earth there is also a magnetic field wherein a compass needle takes a definite direction. So also an electrically charged body is surrounded by an electrical field. At the present time we are immersed in an electromagnetic field, witness these rays of light perceived by our eyes, and the radio or wireless waves which now at all times penetrate even through our homes and very bodies. Attention should be directed to the important fact that there may be complete overlapping of fields. At one and the same place gravitational, electric and magnetic fields coexist. Hence the efforts of Einstein and of Eddington to get one, and only one, "field" which will give a full description of all gravitational and electromagnetic events.

Three things are essential for perception: the source or broadcasting station; the receiver, which must be duly tuned to the source, and the transfer of energy through space. Thus the atoms in the sun broadcast light to us, but we perceive with our eyes only those rays to which our eyes are tuned—that visible octave which is but a fraction of the great spectrum of total radiation.

The importance of correct tuning is now well understood in radio reception, as in all electromagnetic fields, but it is desirable to realize its wider applications. Conversation in the ordinary sense is not possible either by the dumb or to the deaf. The one lacks the transmitting power of speech, the other the receptive power of hearing. Now there are also mental or intellectual fields where a thinker has ideas which he wishes to convey by speech or writing to other intelligences who are willing to understand and receive them. Who can overemphasize the importance not only of intellectual capacity, but also of sympathetic tuning in all mental fields, wherein again form, structure and style are nearly as important as subject or substance?

No less is this true in all forms of art. It is the glory of the artist to create an artistic field. Appreciation of this field by the observer or recipients again depends on the receptivity both as regards capacity, and quality or value. In mental and artistic fields all the precision of mathematical physics is lacking. Measurable quantities are entirely absent. Judgment, good sense and experience are the sole guides of value. But there is beyond all this, indefinable and precious, that inspiration and genius which persuade us that there is something more and something greater than we can include and define in purely physical fields. Yet if we are going to chop up the universe into wholly independent regions, we at once lose that simplicity and generality which it is our hope and ambition to achieve. It is believed that when conflict arises between two domains of thought, for example, religion and science, the reason for such conflict resides in our limited knowledge and intelligence. When conflicts occur in nature, readjustment necessarily and inevitably corrects them.

Greatest of all are those fields where the spirit of man is tuned to the spirit of the universe, so that man is, as it were, a god, or is in complete communion with God.

Are these ideas idle dreams or fantastic visions? No! We can claim as much reality for spiritual fields as for mental, artistic or physical fields. "By their fruits ye shall know them!" Here indeed may be the secret of secrets! The direct evidence of spiritual fields is found in the attributes and experience of those who, finding themselves *en rapport* with the divine light, bear testimony, by their lives, by their actions, by their thoughts, by their influence, that the inner light guided by reason is no mere illusion or dream.

I choose two illustrations. Mr. Baldwin, politician and statesman, lately premier of England, states:

> For myself I say that if I did not feel that our work and the work of all others who hold the same faith and ideals, whether in politics or civic work, was done in the faith and the hope that some day, maybe a million years hence, the kingdom of God would spread over the whole world, then I would have no hope, I could do no more work and I would give my office over this morning to any one who would take it.

These words of Mr. Baldwin's evoke admiration and awake an echo in our souls. And yet—there is a stage even more noble, where those who feel that they are playing a losing game or know that they are fighting a hopeless battle persevere in their undaunted quest for the truth, which includes all that is good and beautiful, persevere in scorn of consequence.

Yet one more witness by a woman, who, in face of disappointments, ill health and approaching death, wrote that fine swan-song, "No coward soul am I!" concluding with her life's vision:

> With wide embracing love
> Thy Spirit animates eternal years
> Pervades and broods above
> Changes, sustains, dissolves, creates and rears
> Though earth and man were gone
> And suns and universes ceased to be
> And thou wert left alone
> Every existence would exist in Thee.
>
> —*The last poem of Emily Brontë*

OBITUARY

WILLIAM HENRY NICHOLS

DR. WILLIAM H. NICHOLS, past president of the American Chemical Society and widely known as a leader in chemical industry, died at Honolulu, Hawaii, on February 21, after a brief illness. He was born in Brooklyn, N. Y., on January 9, 1852, attended the Brooklyn Polytechnic Institute for two years and completed his college course at New York University, from which he graduated in 1870. His later collegiate degrees included the M.S. from New York University in 1870, the LL.D. from Lafayette in 1904 and from New York University in 1920, and the Sc.D. from Columbia in 1904, from Pittsburgh in 1920 and from Tufts in 1921. His choice of chemistry as a career was the result of the influence of John William Draper, under whom he studied at New York University.

Dr. Nichols's career in the field of industrial chemistry began in 1870, when he started a small manufacturing business in which because he had not yet reached his majority he was obliged to use the name of his father in the firm name. The growth of his interests is not merely a parallel to that of the chemical industry during the sixty years which followed, but is itself a significant part of the industry. The Nichols Chemical Company, the Nichols Copper Company, the Benzol Products Company, the National Aniline and Chemical Company and most recently the Allied Chemical and Dye Corporation represent progressive growth in magnitude of enterprise and in value of products, the latter company being one of the largest chemical corporations in this country. These growths were accomplished not solely by business enterprise but also by discoveries of a fundamental character in the industry, such as the first American usage of iron pyrites in the manufacture of sulphuric acid, the first production of electrolytically purified copper for commercial use and the adaptation to American conditions of the synthesis of ammonia from nitrogen and hydrogen, which his company had worked out on an experimental scale as early as January, 1914, before the outbreak of the World War.

Dr. Nichols was one of the organizers of the American Chemical Society in 1876 and was its president in 1918 and 1919. He was president of the Society of Chemical Industry in 1904–05, and chairman of the Eighth International Congress of Applied Chemistry, held in New York City in 1912. His service to collegiate education included membership on the governing boards of the Brooklyn Polytechnic Institute and of New York University for a considerable period of years; he acted as vice-chairman for the former institution and for the latter as vice-president of the council and for a period as acting chancellor. Throughout these years he was a generous contributor also to the financial needs of both colleges, his gifts including among others the Nichols Laboratory of Chemistry at New York University, completed in 1927 at a cost of $700,000. His will included a large number of charitable bequests to various religious organizations, to the American Chemical Society, to the Brooklyn Polytechnic Institute and a residuary legacy to New York University estimated at a value of about two million dollars.

ARTHUR E. HILL

NEW YORK UNIVERSITY,
MAY 5, 1930

J. ARTHUR HARRIS[1]

THE real scientist must have interest in his chosen field of knowledge and a belief in the importance of that field. To this he must add a broad conception of its scope and limitations, ability to distinguish between the essential and the unessential, and diligence in examining every scrap of evidence which bears on the subjects within his field. All of these characteristics J. Arthur Harris possessed in unusual degree. His industry was untiring. He had no schedule of working hours when a problem was to be solved. Nothing was too insignificant for serious consideration and nothing too important to escape investigation. With this was a broad-minded consideration for the views of others, even though opposed to his own, and a keen scientific interest in attempting to see to what extent they would add to his own knowledge of the subjects under discussion. These qualities brought him wide recognition not only within the institutions with which he was associated, but throughout the country and far beyond.

A distinguished student of Karl Pearson, he was a pioneer in the introduction of the biometric method in the domain of botany and in biological science in general. His accomplishments in this field included both the application of quantitative methods to the study of living things and also fundamental contributions to the logic and theory of scientific method. In recognition of these attainments he received in 1921 the Weldon Medal and Memorial Prize of the University of Oxford, the highest award of merit in this field of science.

The laurels which he earned in the field of biometry would suffice for most men but not for him. In the field of ecology he blazed new trails, brought in new conceptions, new quantitative technic, and adapted the study of the newer science of physical chemistry to his pioneer field studies in plant geography. He believed in studying plants in their own environment, and he carried his paths through the morasses of the Dismal Swamp and the Everglades, through the montane rain-forests of Jamaica

[1] Resolutions adopted by the faculty of the College of Science, Literature and the Arts, the University of Minnesota, April 28, 1930.

and Hawaii and through the deserts of Jamaica, Arizona and Utah. He bore personally much of the expense of such field studies, and the advancement of science was the only reward he claimed.

In 1924 he came to the University of Minnesota. With remarkable rapidity he won the admiration and love of his colleagues and the advanced students. He was a great teacher, broadly trained, earnest and sympathetic. At his feet sat the students from nearly all of the various fields of science represented in our university. They acknowledged him as master—they were proud to call him friend.

It was not only in the laboratory, in the field and the classroom that Dr. Harris was eminent. He possessed administrative gifts to a high degree. Official routine was not pleasant to him and he did not consider it a matter to be regarded too seriously if the desired results could be legitimately obtained through short cuts. In his relations with his colleagues, both within his department and without, he was always a gentleman, careful to observe the amenities in every way and to make the work of others easier, while his own efforts were being directed to greater efficiency within his own department. He was generous in recognition of the abilities of his colleagues and he exerted himself to the utmost to secure for them congenial working conditions. It was his ambition, only partly realized on account of his untimely death, to make the University of Minnesota a widely known institution of recognized merit for biological research. The laboratory, the herbarium and the library were all objects of his deepest interest as auxiliaries to this main object.

He was not only a scientist of note and an executive who obtained results, but a congenial companion as well. He was at home in any circle. His wide interest in things outside his own field was acute, his sense of humor prevented him from becoming one-sided or narrow. His genuinely tolerant attitude made it easy to discuss with him things which in most circles would be matters of controversy. In his passing, the University of Minnesota has lost one who can never be replaced as scientist, administrator and friend.

Prepared by the Committee
Royal N. Chapman
Ross Aiken Gortner
Richard E. Scammon
Frank K. Walter
C. Otto Rosendahl, *Chairman*

RECENT DEATHS

Dr. Thomas E. McKinney, from 1908 to 1928 professor of mathematics in the University of South Dakota, died on April 14, aged sixty-six years.

Dr. L. J. Weinstein, who recently was appointed professor of metallurgy at Northwestern University, died on May 14 at the age of forty-nine years.

Dr. Ernest Clement Angst, assistant professor of botany and bacteriology at the University of Oklahoma, died on April 18.

Dr. Grace Barkley, assistant professor of botany in DePauw University, died on April 1, from cerebral hemorrhage resulting from a fall. Her principal contribution was a cytological study of the origin of the spiral markings of protoxylem.

Dr. George Dimmock, of Springfield, Mass., known for his contributions to entomology, died on May 17, his seventy-eighth birthday.

Dr. Fridtjof Nansen, distinguished as explorer, man of science and statesman, died on May 13.

MEMORIALS

A memorial meeting to the late Arthur M. Miller, for thirty-five years professor of geology at the University of Kentucky, will be held on May 30 at his home "Maxwelton," which Professor Miller gave to the university several years ago. The chief speaker at the meeting will be Dr. Collier Cobb, professor of geology at the University of North Carolina, who was associated with Professor Miller for 40 years, consulting with him as late as 1928 in the drawing up of a new geological map for North Carolina. Dr. Austin R. Middleton, zoologist and biologist of the University of Louisville, will officially represent the Science League of America. Dr. W. D. Funkhouser, dean of the Graduate School of the University of Kentucky, will speak of Professor Miller's work. James H. Gardner, president of the Gardner Petroleum Company of Tulsa, Okla., an alumnus of the University of Kentucky, Rolla R. Ramsey, professor of physics at the University of Indiana, and Dr. Walter H. Reynolds, Presbyterian minister at Liberty, Ind., are also on the program. Dr. W. R. Jillson, state geologist, will preside at the meeting.

In memory of the late Sir Baldwin Spencer, who was professor of zoology in the University of Melbourne, it has been decided to place a bronze medallion in the zoology library in the university. Mr. Paul Montford has been commissioned to prepare this medallion, and old students of Sir Baldwin Spencer are invited to contribute towards the cost, which will be a hundred guineas. Donations should be sent to Sir Thomas Lyle, Lisbuoy, Irving Road, Toorak, S.E.2, Victoria, Australia.

The council of the University of Manchester has accepted a bronze plaque of the late Professor W. H. Perkin from a number of his former students and friends, and it will be unveiled in the Chemistry Theater on May 24.

SCIENTIFIC EVENTS

THE AMERICAN ENGINEERING COUNCIL AND AVIATION

ENGINEERS throughout the United States, as represented in the thirty national and local organizations forming the American Engineering Council, have formally placed themselves at the service of the nation's commercial aviation for the solution of basic technical, operating and safety problems now affecting the industry.

This action, taken through the administrative board of the council, in effect enlists 60,000 technical men in all phases of engineering as a consulting body for the promotion of commercial flying.

Formulation of fundamental principles which will serve as a guide in the selection, design and operation of airports and airways and a large program of research to develop safer and more efficient airports and operation methods are among the first tasks proposed by the council, the president of which is Dr. Carl E. Grunsky, of San Francisco.

The results of this work will be disseminated through the Bureau of Aeronautics of the U. S. Department of Commerce as the logical clearing house for such information. By this system the council plans to make its findings available at once to all technical men engaged in aviation problems.

On the ground that it is "the clear duty of the professional engineers of the United States to assist in the development of sound engineering and economic principles" for American aeronautics, the council has acted on a report of its committee on airports, of which Professor Ralph J. Fogg, head of the Department of Civil Engineering in Lehigh University, is chairman. The committee, having come to a decision as a result of its study, has made the following recommendations:

1. That American Engineering Council, as an organization dedicated to the service of the community, state and nation, and as representative of all phases of engineering, become actively interested in the broad engineering and managerial aspects of commercial aviation, and particularly airports.

2. That American Engineering Council wholeheartedly cooperate with the Bureau of Aeronautics of the Department of Commerce in such joint efforts as it may undertake in formulating and disseminating general principles relating to commercial aviation for the guidance of the public.

3. That American Engineering Council create at once a general committee on commercial aviation, with the addition of such sub-committees as may be necessary from time to time, to make a complete study of all aspects of the engineering problems involved.

4. That American Engineering Council adopt the policy, in its cooperation with the Bureau of Aeronautics, of having the sub-committees act on invitation as the council's representative on joint committees.

5. That American Engineering Council accept the invitation received from the Bureau of Aeronautics to join in a cooperative study of the coverage and drainage of airports.

6. That there be organized at once a sub-committee to participate in the joint study of airport coverage and drainage.

Other members of the council's committee on airports are: Perry A. Fellows, city engineer, Detroit; W. W. Horner, chief engineer, St. Louis; Dr. Harrison E. Howe, editor, *Industrial and Engineering Chemistry,* Washington; Alexander Klemin, head of the Guggenheim School of Aeronautics, New York University; H. G. Shirley, commissioner of highways, Richmond, Va.

STATE APPROPRIATIONS FOR CORNELL UNIVERSITY

THE New York State Legislature, recently adjourned, made appropriations for a number of important expansions or new activities for the State Colleges and Experiment Stations at Cornell University. Among the more significant of these was an appropriation of $510,000 to be used with an appropriation of $485,000 made by the legislature of the preceding year for the erection of a new building for the work in home economics; authorization to enter contracts for a new building for agricultural economics and rural social organization at a cost of $650,000, and an appropriation of $285,000 for a new horticultural research laboratory at the State Experiment Station at Geneva. A grant of $400,000 was made for the equipment of the plant science building now nearing completion, which will cost $1,000,000. In addition to these major items the regular budget of the College of Agriculture was increased by $82,020 and there were incorporated as permanent funds $51,050 of special grants made for animal husbandry developments the year preceding.

The following special items were also appropriated: Construction of barns and facilities for animal husbandry, $100,000; purchase of additional land for animal husbandry purposes, $60,000; office and laboratory building at Long Island Vegetable Research Farm, $13,000; addition to tool shed for Long Island Vegetable Research Farm, $1,000; grading, walks, roads, etc., for plant science building, $15,000; investigations for control of Oriental peach moth, apple maggot, etc., by the State Experiment Station at Geneva, $37,000; for the survey of agricultural re-

sources of the state $20,000; for investigation in the spraying and dusting of potatoes on Long Island, $16,500; for extension work in potato growing, $5,500; for investigation in grading and handling of vegetable crops, $5,800; for investigation in control of insects affecting muck soil crops, $6,010; for investigation in control of insects affecting potatoes, $4,000; for an experiment to determine the optimum percentage of protein in a dairy ration, $5,900; for equipment and maintenance of The Western New York Egg Laying Contest, $30,000; for equipment and maintenance of The Central New York Egg Laying Contest, $30,000; for additional state support of County Farm and Home Bureaus and Junior Extension Work, $40,500.

Another legislative enactment of outstanding importance to the State Colleges at Cornell University was a bill admitting all of the staff and employees of these institutions to the privileges of the State Retirement System. Because of the generous character of this system, this provision is considered to be a distinct benefit by members of the staff.

THE UNIVERSITY OF MEXICO AND DR. HOLLAND

Dr. W. J. Holland, on May 2, 1930, completed the installation of a replica of the skeleton of *Diplodocus carnegiei* donated by Mrs. Andrew Carnegie through the Carnegie Corporation of New York and the Carnegie Museum of Pittsburgh to the National Museum of Natural History in Mexico City. Dr. Holland had with him as his chief mechanical assistant Mr. Louis S. Coggeshall, of the section of paleontology in the Carnegie Museum.

On the morning of May 2 a convocation of the trustees and faculty of the National University of Mexico was held in the Casa del Lago in Chapultepec Park, the rector of the university, Señor Dr. Ignacio García Téllez, presiding, supported by Professor Dr. Isaac Ochoterena, the director of the Natural History Museum, and president of the Instituto de Biologia. The rector of the university at the commencement of the meeting announced that the University of Mexico by the action of its duly constituted authorities had made Dr. Holland "Professor Extraordinario de Biologia," and handed Dr. Holland a diploma to that effect. The position is purely honorary and has only been conferred a few times upon distinguished men of science in Europe and Mexico.

In response to the address of the rector Dr. Holland said that he was acting as "the unofficial ambassador of one of the queens of American society, whose husband, the late Andrew Carnegie, had shown in more than royal manner his desire for the establishment of cordial and everlastingly pacific relations between all nations of the Western Hemisphere through his gift to the Pan American Union of a palatial home in Washington." He dwelt upon the important part which men of science may take in promoting a good understanding among the nations. He said that, "while in the past men who bear arms by sea and land had been relied upon to preserve peace, he hoped the day is not far off when men whose weapons are the microscope, the telescope, and the chemist's retort, may prove their superiority to lethal weapons." He concluded by expressing his deep interest in the scientific researches which are now being carried on in Mexico by men whose methods and spirit are thoroughly abreast of modern times.

HONORS CONFERRED BY THE FRANKLIN INSTITUTE

At the Medal Day exercises of the Franklin Institute, held on May 21 in the hall of the institute, the following honors were conferred:

Honorary membership was bestowed upon Dr. M. E. Cooley, dean emeritus of engineering of the University of Michigan, in recognition of inspiring guidance in engineering education, and of friendly reasonableness, enlightened judgment and fearless integrity in the principles of his profession. Dean Cooley had been a professor of mechanical engineering since 1881 and dean of the College of Engineering, University of Michigan, since 1904.

Dr. Henry Leffman, retired chemist, also received honorary membership, in recognition of valuable services to science in research, in teaching, as former port physician of the City of Philadelphia and as a discriminating but good-tempered critic.

A Certificate of Merit was presented to Mr. Heyman Rosenberg, Parker-Kalon Corporation of New York City, in consideration of the successful modification of screws, consisting of hardening the threads, thus permitting them to thread their own way when driven or turned into the material to be joined, and the invention whereby the diameter of the body at the base of the thread is less than that of the cylindrical end.

Edward Longstreth Medal—founded in 1890 by Edward Longstreth, Philadelphia.

Mr. Ervin George Bailey, president of the Fuller-Lehigh Company, Fullerton, Pennsylvania, in consideration of his invention and development of regulating and controlling devices and measuring and recording instruments.

Professor Charles Weyl, University of Pennsylvania, in consideration of the ingenious adaptation of mechanical and electrical principles to the operation of an X-ray apparatus which has proved useful in the diagnosis of certain diseases in their early stages of development.

John Price Wetherill Medal—founded in 1925 by the family of the late John Price Wetherill.

Mr. C. S. Chrisman, formerly with the United Gas Improvement Company and now retired, of West Chester, Pennsylvania, in consideration of his ingenious and economical improvements in the apparatus for, and methods of, gas manufacture.

Mr. W. N. Jennings, business photographer, Philadelphia, in consideration of his pioneer work in the photography of flashes of lightning.

Walton Clark Medal—founded in 1926 by the United Gas Improvement Company, in honor of Dr. Walton Clark, former chief engineer of that company and for many years president of the Franklin Institute.

Mr. Henry L. Doherty, president of the Cities Service Company, New York City, in consideration of his outstanding and valuable work in the development of the manufactured gas industry.

George R. Henderson Medal—founded in 1924 by Mrs. Virginia P. C. Henderson, in memory of her husband, a consulting engineer in Philadelphia and a member of the Board of Managers of the Franklin Institute.

Mr. George Hannauer and Mr. Edgar M. Wilcox, jointly, in consideration of the development of the Car Retarder System and contributions to railway engineering. The work for which the medals are awarded was done jointly by these two gentlemen. Unhappily, Mr. George Hannauer died before the award was completed. Mr. Wilcox, secretary of the Hannauer Car Retarder Company, of Gibson, Indiana, will be present to receive his medal in person, while the late Mr. Hannauer will be represented by his son.

Louis Edward Levy Medal—founded in 1923 by the family of Louis E. Levy, of Philadelphia. Mr. Levy was a member of the institute's Committee on Science and Arts, and vice-president of the institute. He was an inventor and photoengraver.

Professor Floyd K. Richtmyer, department of physics, Cornell University, because of the excellence of his paper which appeared in the *Journal* of the Franklin Institute in September, 1929, entitled, "Some Secondary Phenomena in X-ray Spectra."

Elliott Cresson Medal—founded in 1848 by Mr. Elliott Cresson, who was very much interested in the work of the Franklin Institute. This award is very highly prized and is next to the Franklin Medal in importance.

Mr. Norman Rothwell Gibson, vice-president and chief engineer of the Niagara Falls Power Company, in consideration of his originality in first adapting a well-known law of mechanics to the measurement of flowing water, his skill and ingenuity in developing apparatus for accurately recording the required data, the simplicity, accuracy and economy of his method, the wide scope of its application in measuring the flow of liquids and its very general adaptation in commercial work.

Mr. Irving Edwin Moultrop, chief engineer, the Edison Illuminating Company of Boston, in consideration of the engineering skill displayed in the design and construction of the high-pressure installation of the Edgar Station, whereby a marked advance in the art of steam electric generation was accomplished and a reliable source of information for advance predication, not only of performance but of initial cost of such stations, was made available, and in which courage of high order was manifested.

Franklin Medal—founded in 1914 by Samuel Insull, Esq., of Chicago, to be awarded to those workers in physical science or technology, without regard to country, whose efforts, in the opinion of the institute, acting through its Committee on Science and the Arts, have done most to advance a knowledge of physical science or its applications.

Dr. John Frank Stevens, retired engineer, former chief engineer, the Panama Canal, in recognition of his unifying solutions of widely varying and difficult engineering problems met in the planning of the great Panama Canal, of the marked power shown by him in the organization of the engineering forces which later built that canal and of his eminent success in the location, construction and administration of railroads in this country and in foreign lands.

Sir William Bragg, director, the Royal Institution of Great Britain, London, in recognition of a life work in the study of X-rays and radioactivity, in the course of which he made fundamental contributions to that realm of physics, of his development of a method of determining molecular and crystal structure by the reflection of X-rays and of his fruitful guidance of the Davy-Faraday Research Laboratory and the Royal Institution of Great Britain.

Immediately after the presentation of the medals, Dr. John Frank Stevens read a paper entitled, "A Momentous Hour at Panama," in which he recounted some hitherto unpublished happenings in the building of the canal. Sir William H. Bragg delivered a paper on "The Meaning of the Crystal," a short article based upon his own researches of the meaning of the crystal in nature. On the evening of Medal Day, the Franklin Institute had as its guests of honor the medalists of the day at a dinner held at the Bellevue-Stratford.

Following his appearance in Philadelphia, and under the auspices of the Franklin Institute, Sir William H. Bragg will deliver a series of three lectures, based upon his own important work and discoveries in the realm of physics. He will speak at Columbia University, Johns Hopkins and Princeton. He will also be the guest of honor at a colloquium to be held at the Bartol Research Foundation Laboratory of the institute. Sir William will also broadcast over WCAU on the afternoon of Thursday, May 29. He plans to remain in this country for several weeks, attending various scientific meetings. He will be accompanied by his daughter.

SCIENTIFIC NOTES AND NEWS

A luncheon in honor of Dr. A. E. Kennelly, professor of electrical engineering at Harvard University, was recently given at the Harvard Club of Boston to mark the completion of twenty-eight years of service to the university. Dr. Kennelly is retiring from active service at the end of the present academic year. A silver loving-cup, suitably inscribed, was presented to him by his colleagues in the Harvard Engineering School. Brief remarks were made by President A. Lawrence Lowell and by Dr. Kennelly.

The Willard Gibbs Medal of the Chicago section of the American Chemical Society will be presented to Dr. Irving Langmuir following a dinner to be given in the Palmer House, Chicago, on the evening of May 23. Dr. Langmuir's address will be on "What are Atoms Like?—How do We Know?" He will be followed by Dr. Karl T. Compton, of Princeton University, president-elect of the Massachusetts Institute of Technology. Shorter addresses will be made by President Glenn Frank, of the University of Wisconsin; Dean R. E. Heilman, of Northwestern University; Dr. Herman Bundesen, coroner of Cook County, Illinois, and Mr. Martin Insull, of the Midwest Utilities Company. The medal will be presented to Dr. Langmuir by Professor Julius Stieglitz, of the University of Chicago.

Dr. James G. Needham, professor of entomology at Cornell University, has been designated by the Peking Society of Natural History as the first recipient of the King Senior Memorial Gold Medal in recognition of his contributions to the knowledge of the fauna and flora of China.

Villanova College will present its 1930 Mendel Medal, awarded annually for distinguished service in the advancement of science, to Albert Francis Zahm, chief of the division of aeronautics in the Library of Congress, Washington, D. C.

Marvin R. Thompson, assistant pharmacologist of the Food and Drug Administration, U. S. Department of Agriculture, is the winner of the Ebert medal awarded by the American Pharmaceutical Association. The prize goes to the author who at the annual meeting of the association presents the paper "contributing most to the science of pharmacy." Mr. Thompson, who is twenty-four years old, is the youngest man to receive this award. His subject was "The Pharmacology of Ergot."

The Fritz Schaudinn Medal, in commemoration of the discoverer of *Spirochaeta pallida,* has been awarded for outstanding work in microbiology to Professors M. Hartmann, Berlin, F. d'Herelle, formerly of Paris, and now at Yale University, and to E. Reichenow, Hamburg. The award was made on March 3, the twenty-fifth anniversary of the discovery of the micro-organism causing syphilis, by an international committee of jurors appointed by the Tropical Institute in Hamburg.

At a meeting of the Linnean Society of London on May 1 the president announced that the Linnean Gold Medal for 1930 had been awarded to Dr. James Peter Hill, F.R.S., professor of embryology, University College, London, and would be presented at the anniversary meeting on May 24. On the same date the Trail Award and Medal will be presented to Dr. Kathleen Bever Blackburn, of the botanical department of Armstrong College, Newcastle-on-Tyne.

An honorary life fellowship of the Ross Institute was recently bestowed on Rai G. C. Chatterjee Bahadur, Bengal, India, for his work in malaria control.

Dr. John D. Clark, professor of chemistry at the University of New Mexico, Albuquerque, has been elected president of the Southwestern Division of the American Association for the Advancement of Science.

Dr. Walter A. Bastedo, of New York, was elected president of the United States Pharmacopoeia at the recent decennial convention in Washington. Dr. H. A. B. Dunning, of Baltimore, was elected vice-president. Among those elected to the revision committee are Dr. Reid Hunt, professor of pharmacology, and Dr. Henry Christian, professor of medicine, both of Harvard University, and Dr. C. W. Edmunds, of the University of Michigan.

Dr. Henry C. Christensen, Chicago, secretary of the National Association of Boards of Pharmacy since 1914, was elected president of the American Pharmaceutical Association at the recent Baltimore meeting. Other officers are: E. F. Kelly, of Baltimore, *secretary;* Walter D. Adams, of Forney, Texas, *first vice-president;* D. B. R. Johnson, of Norma, Okla., *second vice-president;* C. W. Holden, of Essex Fells, N. J., *treasurer,* and Drs. H. V. Arny, New York; T. J. Bradley, Boston, and W. B. Day, Chicago, *members of the council.* The convention next year will be held in August at Miami, Florida.

J. B. Fairbairn has been appointed deputy minister of agriculture for Ontario. W. B. Roadhouse, who has been deputy minister since 1912, has resigned in order to accept the chairmanship of the Ontario Agricultural Development Board.

Lieutenant-Colonel Fielding H. Garrison who has been in the United States Medical Service since 1891 has taken up his work as head librarian of the

William H. Welch Medical Library, at the Johns Hopkins University.

Dr. Thomas G. Thompson, professor of chemistry at the University of Washington, was recently appointed to the directorship of the new University of Washington Oceanographical Laboratories. Dr. Thompson's appointment is effective on October 1.

Dr. F. L. Pickett, head of the department of botany at the State College of Washington, has been made dean of the graduate school.

Dr. Fred Griffee, biologist in plant breeding at the Maine Agricultural Experiment Station, Orono, has been made assistant director of the station. Dr. Griffee will assist Director Warner J. Morse, who has been granted a leave of absence because of illness.

Professor A. J. Olney has been appointed head of the department of horticulture at the University of Kentucky to succeed the late Professor C. W. Mathews. Professor Olney, who is a graduate of Michigan State College and the University of Chicago, will be in charge of the experimental work in fruit and vegetable growing at the three experiment stations and will head the teaching of horticulture in the College of Agriculture.

Dr. Paul H. Stevenson, associate professor of anatomy at Peking Union Medical College, will teach in the University of California summer session from June 30 to August 9, in the department of anthropology.

Dr. Willem Van Royen, of the Netherlands Chamber of Commerce, New York City, has been appointed instructor of geography in the University of Nebraska.

Dr. Max M. Ellis, professor of physiology in the school of medicine of the University of Missouri, has been appointed regional director of investigation in the Bureau of Fisheries with the title "In Charge, Fishery Investigations, Interior Waters." He will head a staff of biologists engaged with ecological, fishery and pollution studies in the rivers of the Mississippi River drainage, but will not sever completely his connection with the university. Attention will be directed to perfecting the method of large-scale propagation of fresh-water mussels that has been developed from Dr. Ellis's experiments as a temporary investigator for the bureau since 1926.

Dr. C. L. Huskins, research geneticist and cytologist at the John Innes Horticultural Institution, London, England, is returning to Canada about September 1, to take up his new duties as associate professor of botany at McGill University.

Dr. Alexander Wetmore, assistant secretary of the Smithsonian Institution; Dr. Casey Wood, honorary associate in ornithology of the U. S. National Museum, and Harry S. Swarth, inspector of foreign birds under the Geological Survey at San Francisco, have been designated by the Department of State to represent the United States at the seventh International Ornithological Congress, which will convene at Amsterdam from June 1 to 7. The sixth congress was held at Copenhagen in 1926, at which were present representatives from thirty-two countries.

Dr. George K. Burgess, director of the Bureau of Standards, delivered an address to the Sigma Xi Club of the University of Alabama on May 7.

Dr. Arthur D. Little, president of Arthur D. Little, Inc., addressed the spring meeting of the American Iron and Steel Institute at New York on May 9, on "The Contribution of Science to the Iron and Steel Industry."

Dr. Lafayette B. Mendel, Sterling professor of physiological chemistry in Yale University, gave two illustrated lectures at Cornell University on May 8 and 9, under the auspices of the Jacob H. Schiff Foundation. His subject was: "Some Relations of Diet to the Formation of Body Fat."

Professor F. K. Richtmyer, of Cornell University, addressed two open meetings of the Gamma chapter of Sigma Pi Sigma, honorary physics fraternity, at the Pennsylvania State College, on May 6 and 7. He also spoke to the combined physics and chemistry seminars on the "X-Ray Satellites." Dr. Richtmyer was initiated as an honorary member of the fraternity during his visit.

Dr. Karl F. Herzfeld, professor of physics in the Johns Hopkins University, will lecture at the Cooper Union in New York City on each Tuesday evening during the next college year. These lectures will constitute a survey of the field of modern physics and several evenings will be given to each of the following topics: Crystal structure, absorption and emission of light in the quantum theory, photochemistry, dielectric polarization and the structure of molecules, atomic structure, band spectra and the structure of gas molecules. The lectures have been arranged by the departments of chemical engineering and physics at the Cooper Union and will be open without payment of fees to those who have had the necessary mathematical preparation.

Professor Robert Chambers, of New York University, has been invited by the Physiological Institute in Moscow to give a series of lectures and demonstrations in June on the micromanipulative technique and the physical properties of the living cell. He left for Europe on May 9. In August he will give a lec-

ture with motion pictures at the Cell Physiological Congress in Amsterdam, which meets from August 4 to 9.

PROFESSOR ROBERT H. GAULT, of Northwestern University, is giving a lecture this summer in the following foreign universities: Cambridge, Manchester, Edinburgh, Hamburg, Rostock, Halle (Nose and Ear Clinic) and Leipzig. His subject is "On the Effect of Dual (Tactual-Visual) Stimulation from Spoken Languages and an Analysis of the Effect."

THE first course of Scott Lectures was given by Dr. Niels Bohr at the University of Cambridge on May 12, 14 and 16, on "The Principles of Atomic Theory."

THE twenty-fifth anniversary of the founding of the Harvey Society, New York, was celebrated on May 15, when Dr. Rufus I. Cole gave an address on "The Progress of Medicine during the Past Twenty-five Years, as Exemplified by the Harvey Lectures." Following the lecture the "Harvey Film," prepared by Sir Thomas Lewis and Dr. H. H. Dale, was exhibited. After the meeting there was a supper at the Hotel Plaza. Dr. G. Canby Robinson presided and there were speeches by Dr. John A. Hartwell, Dr. Graham Lusk, Dr. Harvey Cushing and Dr. William H. Welch.

NINE additional chapters of Sigma Pi Sigma, national honorary physics fraternity, are being installed this spring, bringing the roll up to nineteen chapters by the end of the college year. Dr. Marsh W. White, associate professor of physics at the Pennsylvania State College and the national secretary of the society, is conducting the installations. Chapters are being established at the University of Kentucky on May 15, the University of Oklahoma on May 17, Park College on May 19, William Jewell College on May 20, Morningside College on May 21, the University of Colorado on May 22, the University of Washington on May 26, Lake Forest College on May 31 and the College of Wooster on June 2.

THE spring meeting of the Tennessee Academy of Science for 1930 was held in Chattanooga, on April 11 and 12. The meeting was well attended by members from Middle and East Tennessee, representatives of eight educational institutions from these sections of the state having papers on the program. Tennessee caves were discussed Friday afternoon in a "Cave Symposium," and on Saturday afternoon Lookout Mountain Caverns and points of scenic and historic interest in the vicinity of Chattanooga were visited. Two public lectures were given Saturday evening: "Short Wave Length Radio Demonstration," by Francis G. Slack, of Vanderbilt University, and "Principles of Radio Broadcasting and Reception," by C. R. Fountain, of George Peabody College for Teachers. The University of Chattanooga as host for the meeting provided halls and ample facilities for the sessions and generous entertainment during intervals. The academy was privileged to have as a guest Dr. W. J. Humphreys, of the U. S. Weather Bureau, who brought greetings from the American Association for the Advancement of Science and delivered on Friday evening an illustrated public lecture on "Beauties of the Sky—Halo, Rainbow, Lightning and Every Kind of Cloud that Floats." Dr. Francis G. Slack, associate professor of physics, Vanderbilt University, was elected vice-president, in place of Dr. David W. Cornelius, who became president on the death of Dr. F. B. Dresslar, on January 19.

THE Kentucky Academy of Science held its seventeenth annual meeting at Centre College, Danville, on May 3. The president, Dr. Frank L. Rainey, delivered an address on the teaching of science in colleges of liberal arts. Papers were read on many subjects. Dr. A. M. Reese, of West Virginia University, who represented the American Association for the Advancement of Science, gave an illustrated lecture on "The Habits of the American Alligator." The officers elected were: V. F. Payne, Transylvania College, *president;* Mrs. Clara Chassell Cooper, Richmond State Normal School, *vice-president;* A. M. Peter, University of Kentucky, *secretary;* W. S. Anderson, University of Kentucky, *treasurer;* Austin R. Middleton, University of Louisville, representative in the council of the American Association for the Advancement of Science; W. R. Jillson, state geologist, Frankfort, member of the committee on publications. Centre College entertained the academy at luncheon.

THE fifteenth annual meeting of the South Dakota Academy of Science was held at Vermillion, South Dakota, on May 1 and 2. The first session was devoted to papers by the members followed by the president's address—"Incursions of the Cretaceous Sea." On the evening of May 1 a complimentary smoker was given by the local committee at the club house of the Vermillion Golf Association. After the usual academy dinner on May 2 Dr. Raymond J. Pool, of the botany department of the University of Nebraska, spoke on "Wild Life on the High Peaks of the Rockies." The following officers were elected for 1930–31: V. A. Lowry, Eastern State Teachers College, *president;* B. B. Brackett, University of South Dakota, *first vice-president;* J. H. Jensen, Northern State Teachers College of South Dakota, *second vice-president,* and A. L. Haines, University of South Dakota, *secretary-treasurer.*

A FIRE that destroyed one of the main buildings

of Georgetown College, Georgetown, Kentucky, recently, swept the biological laboratories that were located on the second and third floors. Equipment to the value of ten thousand dollars was lost. Enough microscopes were saved to enable the department to begin work immediately in the college gymnasium and no laboratory periods were missed. The department will be housed temporarily in a new building that is being erected on the campus until plans for rebuilding can be completed. The departmental library suffered the loss of files of SCIENCE dating back nearly twenty-five years, many books, herbaria, collections of material and files of several scientific publications. In sending this information Professor Robt. T. Hinton writes: "Any gifts of duplicate copies of SCIENCE, *The Scientific Monthly* and various biological publications would be greatly appreciated if institutions or individuals have them to spare."

THE new building of the School of Pharmacy of the University of Maryland was dedicated on May 10 during the meeting in Baltimore of the American Pharmaceutical Association. The ceremony was held at Old Westminster Church and most of the attending pharmacists visited the tomb of Edgar Allan Poe in the historical churchyard. Dr. Edward Kremers, director of pharmacy at the University of Wisconsin, delivered an address. State and city officials also spoke.

PROFESSOR GEORGE GRANT MACCURDY, of Yale University, director of the American School of Prehistoric Research, has received word from Dr. Hackett, who with Mr. Theodore D. McCown is representing the school in the latter's joint excavations with the British School of Archeology at Jerusalem, that during the first ten days of April no less than 5,000 tools dating from the Aurignacian Epoch of the Old Stone Age were dug from a single cave of the group south of Haifa. Miss D. A. E. Garrod, of the British school, is in charge. The season's excavations will terminate in time for Dr. Hackett and Mr. McCown to take part in the work of the tenth annual summer term of the American School of Prehistoric Research, which will open in Paris on July 1, under the direction of Professor MacCurdy. Assisting him in the field there will be three of his former students: J. T. Russell, Jr., U. S. National Museum; V. J. Fewkes, University of Pennsylvania, and Robert Ehrich, Harvard University.

AN American Committee for International Wild Life Protection has been formed for the purpose of cooperating in every way with existing foreign governments and institutions working for wild life conservation. This committee is made up of representatives of prominent American institutions and organizations interested in these matters, and particularly cooperating in this work with the British Society for the Preservation of the Fauna of the Empire and the Office for International Nature Protection at Brussels. The following institutions have already been elected to the American Committee: Museum of Comparative Zoology—Dr. Thomas Barbour; Field Museum of Natural History—Mr. Stanley Field; Camp Fire Club —Mr. William B. Greeley; California—Major F. R. Burnham. Executive Committee: Dr. John C. Phillips, *chairman*, for the Boone and Crockett Club; Mr. George D. Pratt, for the American Museum of Natural History; Mr. Kermit Roosevelt, for the New York Zoological Society, and Mr. Harold J. Coolidge, Jr., *secretary*, Museum of Comparative Zoology, Cambridge, Massachusetts.

DISCUSSION

THE TAU EFFECT—AN EXAMPLE OF PSYCHOLOGICAL RELATIVITY

IF three spots on the back of the hand or arm are touched lightly with the point of a pencil in quick succession, two spatial intervals will be defined by the three stimulations. If one is asked to judge whether the second spatial interval is equal to, greater than or less than the first interval, it will be found that the observer's report depends more upon the time interval between stimulations than upon the actual distances between places touched. The same has been found to hold true in vision, hearing and the estimation of the extent to which the hand or arm has been moved through space. Thus, if we stimulate three spots on the skin so that the first distance is 20 mm and the second 10 mm, but the time interval between the second and third stimulations is twice as great as that between the first and second, then the distance between the second and third spots will be judged as nearly twice as great as the first. The conditions may be reversed to give the opposite effect; *i.e.*, by making the second distance twice as long as the first, but the time interval much shorter, the judgment will be that the second distance is very much smaller than the first. While this phenomenon has been reported before in the psychological literature, it has not been labeled in such a way as to give it the independent status it deserves. I therefore propose that it be called the *Tau* effect because it obeys definite laws, can be measured and is not due to "imagination," "attention," "suggestion" or any other peculiarly mental-

istic mechanism. It illustrates beautifully the dependence of space on time in our estimations of visual, tactile, kinesthetic and auditory space. In order to produce the *Tau* effect we may say, in general, vary the time interval in the opposite direction to the space interval and the latter will be distorted accordingly. So easy is it to demonstrate the *Tau* effect that it can be used as a parlor trick or game.

It may be thought that we are here dealing with a lightly dispelled illusion or error in judgment in which the subject unwittingly is judging the time intervals instead of the spatial distance between the spots touched. Nothing could be farther from the truth, for even when the subject knows what the effect consists in and is due to, if we vary our conditions by reversing the spatio-temporal relations, the subject will be wholly lost as to whether or not the spatial intervals are really equal or different and in what sense they differ. We have here, I believe, a *bona fide* example of the interdependence of time and space. They are so intimately related psychologically, as well as physically, that by varying them in opposite sense it is possible to demonstrate directly to an observer the distortions in space which relativists have told us about. It is interesting to note that whereas it is doubtful if the physicist can ever hope to do more than make relativity an intelligible abstraction to the layman, the psychologist by this simple experiment can directly demonstrate what the interdependence of time and space means in direct experience.

Several factors influencing the *Tau* effect which should be noted if one is to get it at its best are the following: (1) care should be taken to touch all the spots equally so that no one stands out more than another; (2) the greater (or less) the spatial distance between the second and third stimuli as compared with the first and second, the less (or greater) must the time interval be between the latter as compared with the former, if the effect is to appear; (3) the optimal effect is limited by the actual spatio-temporal intervals used: we have found that distances as great as 80 mm on the back of the arm and times as long as 1 second may be used. There is practically no lower time limit, although the second temporal interval should not bear a greater ratio to the first than 3 or 4 to 1.

A fuller, quantitative account will appear in one of the psychological journals.

Harry Helson

Bryn Mawr College

ON THE AGE OF THE NEW ALBANY SHALE

In an interesting article on "Petrified Wood in the New Albany Shale," published in Science for December 13, 1929, Chester A. Arnold described an occurrence of fossil wood in the upper part of the New Albany shale in Scott County, Indiana, which he referred to the genus Callixylon. The concluding paragraph of his contribution is as follows:

> Although the wood is widely scattered, it appears to occur mostly near the top of the New Albany formation. While formerly considered as belonging to the upper Devonian and of the same age as the Genesee shale of New York, the New Albany shale is now viewed by some competent authorities as being, at least in part, of lower Mississippian age. This would place the Indiana wood in the Mississippian, and thus extend the range of Callixylon from the Devonian up into the Carboniferous. However, there is no record of its occurrence any higher than this basal member.

It seems to the present writer that Mr. Arnold is not justified in his conclusion quoted above. The New Albany shale as it occurs in the type locality in the vicinity of New Albany, Indiana, is a definite formation. Other black shales present in eastern Ohio, Kentucky and Tennessee, east of the Cincinnati anticline, were until a few years ago thought to be the equivalent of the New Albany shale at New Albany, Indiana. In recent years a part of the black shale in eastern Ohio, Kentucky and Tennessee has been shown to be of early Mississippian age. However, this does not prove that any part of the New Albany shale at New Albany, Indiana, is younger than the Upper Devonian, but rather that such part of the black shale of eastern Ohio and Kentucky as is now known to be of early Mississippian age is younger than any part of the typical New Albany shale at New Albany, Indiana. So far as known to the present writer, no one has ever shown that any part of the New Albany shale, as it is developed in the type locality near New Albany or farther north in Indiana or south in Kentucky, west of the Cincinnati anticline, is younger than upper Devonian age. Therefore, it seems that the more logical conclusion to be drawn from the occurrence of Callixylon in the upper part of the New Albany shale in Scott County, Indiana, would be that this shale is of upper Devonian age, because the genus of fossil wood that occurs in it has never been found in strata younger than the Devonian.

T. E. Savage

University of Illinois

FIREFLIES FLASHING IN UNISON

Several times in recent years correspondents of Science have directed attention to the synchronous flashing of a swarm of fireflies or other insects, as at page 132 in the issue for January 31, 1930.

A theory to explain this behavior of the insects is as follows. Doubtless each individual insect has a normal tendency to flash at approximately equal intervals, these intervals being nearly the same for many different individuals of the swarm. Suppose that in each insect there is an equipment that functions thus: when the normal time to flash is nearly attained, incident light on the insect hastens the occurrence of the event. In other words, if one of the insects is almost ready to flash and sees other insects flash, then it flashes sooner than otherwise. On the foregoing hypothesis, it follows that there may be a tendency for the insects to fall in step and flash synchronously.

Everybody knows the flashing electric glow lamps for advertising and for warning signals. Some of these of longer period (five or ten seconds) have apparatus in which a condition (like the heat expansion of a core by an electric heating coil) builds up with time until it causes a flash which wipes out that condition, which then begins and builds up anew, and so on. Let us have a number of such lamps on a bench with their periods nearly, but not exactly, the same. Suppose that with each lamp there is a respective photoelectric cell connected to intensify the said condition (as by increasing the electric current in the heating coil) when light falls on the cell. First, screen the lamps from each other; there will be no sustained synchronism. Next, remove the screen; with suitable adjustment of the apparatus, the lamps will fall in step and flash in synchronism.

Consider two flashing lamps (or insects) A and B of periods slightly different, A having the shorter period. Eventually there will come a time when B's normal flash will be promptly after A's flash. Thereafter, were it not for the photoelectric cell (or in the case of the insect, the special equipment assumed by the present theory), B would flash later and later compared with A. But because of the cell (or equipment), B is accelerated each time enough to keep it in step with A. Further development of the principle here involved could be reached by extending the discussion to cases of three or more units.

An individual flashing firefly should be confined and its approximate period ascertained by observation, then a light should be flashed in its presence at a period slightly less; would the firefly fall into step? Various intensities and kinds of light should be tried.

Carl A. Richmond

Tyngsboro, Massachusetts

PRESSURE IN A FLUID

W. H. Pielemeier proposes in the issue of Science for April 25 that the concept of pressure potential be introduced, in the treatment of hydrodynamics. It seems to me that he has misconceived the nature of pressure. He states that according to the defining equation, $p = F \div A$, pressure is a vector quantity. This is not the case. In the equation F is a vector normal to the surface, and A is a vector in the same direction. The quotient is a scalar quantity. p is therefore a scalar. Inasmuch as we have already the potential function represented by the product of pressure and the specific volume of the fluid, it seems unnecessary to introduce another potential function so closely related to the one already in use.

H. H. Marvin

University of Nebraska

LAWS OF ORBITAL MOTION

Recent correspondence has directed my attention to a law of planetary distances given in Science for April 5, 1929, by Professor Caswell, who states that so far as he is aware the relation has not hitherto been reported.

As a matter of fact, the law was enunciated by me ten years ago, in *The Observatory,* No. 545, November, 1919, and was shown to apply not only to the Sun and planets but also to systems of satellites.

A. F. Dufton

Greenbank, Garston,
Hertfordshire, England

SPECIAL CORRESPONDENCE

BARRO COLORADO ISLAND BIOLOGICAL STATION

Dr. Thomas Barbour, chairman of the executive committee of the Barro Colorado Island Biological Station in the Panama Canal Zone, has submitted to the division of biology and agriculture of the National Research Council the sixth annual report of the station, covering the period from March 1, 1928, to February 28, 1929.

Dr. Barbour reports that the following institutions have continued their annual $300 table subscriptions: American Museum of Natural History, Harvard University, Missouri Botanical Garden, Smithsonian Institution, Johns Hopkins University and the University of Michigan. He is also glad to be able to announce that the Carnegie Institution and the Field Museum of Natural History have joined the institutions that help support the station through table subscriptions. There should be more.

The total expenses for the year were $6,052.80, and the total income received was $6,489.45. This total was made up by table subscriptions, personal donations (among which Dr. Barbour's account for two

thirds of the sum) and subsistence fees from scientific workers.

The station is given the advantage of various concessions made by the government officials of the Panama Canal Zone and several steamship and railway companies, which greatly lessen the traveling and other personal expenses of investigators. Particulars concerning transportation from the United States to the Canal Zone and expenses while at the station can be had by application to Dr. Thomas Barbour, Museum of Comparative Zoology, Cambridge, Massachusetts. Those planning to work at the station should state approximately when they expect to sail and from which port. In some cases return transportation can be arranged with the steamship company before leaving the United States. Passports are not required in the Canal Zone.

The governor of the Panama Canal issues to visiting scientists a complimentary annual card pass on the Panama Railroad and also a card authorizing purchases in the Panama Canal commissaries. The governor has also generously extended to the working scientists of the station and to their families the same rates at the Gorgas Hospital that apply to families of employes of the Panama Canal. These rates are extremely reasonable and the hospital facilities are excellent in every way. Dr. Barbour's report especially acknowledges the continued cooperation of government officials in every department. Without this constant willingness on the part of these officials to support the station, its maintenance would be far more difficult.

Much has been done during the year in the way of extending trails and of making repairs and additions to the building and material equipment of the station. The old dock has been replaced by a new one. The guest house has been given more ventilation and light. All the buildings have been repainted. Several interesting long-time experiments on termite resistance of various kinds of wood are under way.

Dr. Barbour has prepared a list of papers published since the opening of the station, presenting the results of work done at the station by visiting investigators. This list includes 118 titles. Conspicuous among these publications is the recent book of Dr. Frank M. Chapman entitled "My Tropical Air Castle." This is a charming and authentically informing book of Barro Colorado Island natural history.

During the past year sixteen investigators have worked at the station for varying lengths of time, and about one hundred other persons visited the island.

More financial help is needed by the station for material equipment of one kind and another, and for work to be done on trails and in connection with the buildings of the station. A few thousand dollars more available each year to the station would enable great improvements to be made in it, and afford greatly improved opportunities for the investigators. The cooperation of universities and biological organizations by table subscriptions is the simplest and most desirable way to effect the needed aid. In the meantime, thanks to the generosity of Dr. Barbour and others, the station offers a unique opportunity to those who would work in the American tropics.

VERNON KELLOGG,
Permanent Secretary
NATIONAL RESEARCH COUNCIL

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN ELECTRICAL RECORDING MANOMETER

IT is frequently desirable when studying pressure changes in the circulatory and respiratory systems to be able to photograph simultaneously these pressure changes together with other variables on the same strip of film. Previous set-ups for this purpose demand a rather cumbersome optical system which is particularly disadvantageous because it interferes with the recording of other phenomena on the same film. The recording manometer here described possesses the advantages that it can be easily and cheaply constructed from available laboratory materials, is simple and can be used in conjunction with a multiunit oscillograph, the other elements of which can be utilized for time lines and other desired records.

The constants as given are of course applicable only when used with oscillograph units similar to those employed here, but slight modifications in resistances would adapt it to any oscillograph or fairly high speed galvanometer.

The parts required consist of:

a. an ordinary blood-pressure mercury manometer
b. 900 ohm variable resistor
c. $1\frac{1}{2}$ to 6 volts in dry cells
d. oscillograph or galvanometer
f. connection to resistance wire
g. glass tubing support for resistance wire
h, h, m. resistance wire No. 30 nichrome

The resistance wire is fastened to a length of drawn out glass tubing by means of small sealing-wax bridges. The tubing should be as small as possible and still be firm enough to keep the resistance wire

fairly taut. A free airway must be provided through the cork in the manometer by means of v-shaped grooves cut into the cork. The setting of the variable resistor will be dependent upon the resistance of the

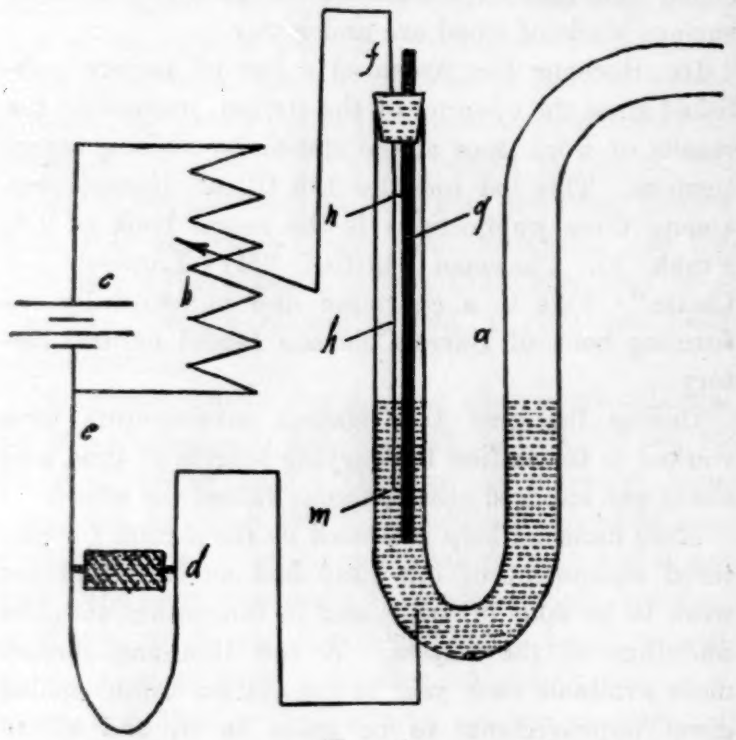

FIG. 1

oscillograph unit, the voltage employed and the sensitivity desired. With a Westinghouse supersensitive oscillograph unit, the deflection at 22 inches optical distance corresponded roughly to the fluctuations of the mercury when the resistance was set at 100 ohms and the battery potential was $1\frac{1}{2}$ volts. All the internal parts of the manometer should be kept scrupulously clean to avoid uneven flow of the mercury and consequent errors in the records.

The same arrangement also should be of value as a myograph for recording muscular contractions by connecting the muscle to a tambour and the tambour to the manometer.

RICHARD H. FITCH
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DEPARTMENT OF PHARMACOLOGY,
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PLANT JUICE CLARIFICATION FOR NITRATE NITROGEN DETERMINATIONS

THE introduction of the small laboratory hydraulic press has stimulated scientific investigation concerning the chemical composition of plant juices. Phosphorus and potassium may be determined to a fair degree of accuracy, but the determination of nitrogen existing in the juice as nitrate presents difficulties that are almost insurmountable because of the organic matter present. In plant juices the nitrates are usually determined by the colorimetric phenoldisulphonic acid method on account of its rapidity and ease of manipulation. In order to obtain reliable results a clear solution of the juice is absolutely essential. Many clarifying agents have been used, such as copper sulphate, iron hydroxide, aluminum hydroxide, calcium carbonate and a host of other substances. These reagents have not always been satisfactory because of brown tints which are developed when the evaporated portion is compared with a standard nitrate solution. Using the expressed juice from the corn plant the following method has given clear extracts and clear tints when matched with a standard in a colorimeter. The method as developed in this laboratory is as follows.

Measure out 10 cc of the corn juice into a small evaporating dish. Add sufficient silver sulphate to precipitate any chlorides that may be present. Evaporate the solution containing the silver sulphate to dryness on a water bath. Cool and rub up the residue using cold water. Transfer to a 200-cc graduated flask, make up to mark and filter off 100 cc of the solution. Transfer the solution to a Nessler tube 3 cm in diameter and 20 cm in length fitted with a 2-hole rubber stopper carrying a tube reaching to the bottom of the liquid and a shorter one just passing through the stopper. Add 2 grams of G. Elf carbon black and mix thoroughly. Attach the shorter tube to a suction pump and aspirate for four hours at the rate of 30 bubbles per minute. Filter through two dry 11 cm S. and S. filter-papers and take 10 cc of the clear filtrate for the determination of nitrogen as nitrate. Evaporate to dryness and add 2 cc of the phenoldisulphonic acid reagent and allow to stand for 10 minutes on a beaker filled with cold water. This keeps the dish cold while the reaction is taking place. Add 20 cc water and allow the residue to dissolve slowly. Cool thoroughly and develop the yellow color with 1 to 1 ammonium hydroxide solution and make to a volume of 100 cc. Compare with a standard nitrate solution in a Duboscq or other standard colorimeter using a standard potassium nitrate solution containing 0.1 milligram of nitrogen to each 100 cc of water.

By evaporating and drying the juice at the temperature of boiling water and taking up with cold water a solution is obtained which is easily clarified by carbon black, and the clarification appears to be intensified by passing a slow current of air through the solution which keeps the carbon black continually moving. This method of clarification has been tried on corn juice with success, and further studies as to its perfection and application to other plant juices are now under way.

H. H. HILL
VIRGINIA AGRICULTURAL
EXPERIMENT STATION

SPECIAL ARTICLES

THE ISOLATION OF NITROSOMONAS AND NITROBACTER BY THE SINGLE CELL TECHNIQUE[1]

SINCE the classical work of Winogradsky in the late eighties, numerous attempts have been made to isolate the nitrifying organisms, but with few exceptions these have failed, and his work in its entirety has never been repeated. He used a modification of the plate method of Koch, and after overcoming many difficulties reported the isolation of both groups. The failures in isolation of these organisms have been due largely to the use of the plate method, a method which is not satisfactory for slowly growing organisms which do not readily form colonies.

These specialized organisms are usually cultivated in highly selective media and the cultures are called enrichments. For example, the only energy source in the medium for the study of the *Nitrosomonas* group is an ammonium salt and for the *Nitrobacter* group, sodium nitrite. Theoretically the bacteria which are unable to utilize these sources of energy should die out and those which are able to utilize the energy should increase in numbers. In a general way this is what happens, but it is not the whole story. If it were it would be an easy matter to make a few transfers followed by dilutions and in this way secure a pure culture of the desired form. In practice, however, all the dilution experiments have failed to yield pure cultures. As noted above, Winogradsky reported successful results by the use of the plate method and a few others have also reported isolations, but the vast majority have failed. This is due to the fact that most of the colonies which form on the plates contain other organisms which do not oxidize the ammonium salt or the nitrite. Furthermore, these colonies are microscopic and hard to study or to use for isolations. The criterion of purity (the failure to grow when inoculated into nutrient broth) is not satisfactory.

In the spring of 1928 the author began some studies on nitrifying organisms using the plate method. The results were not satisfactory. When the work was resumed in the following November, it was thought worth while to try the isolation of the organisms by picking single cells from the enrichment cultures. The first trials were very discouraging; it was slow and tedious to isolate organisms from the cultures having insoluble carbonates present which is the case in *Nitrosomonas* cultures. Of the first 365 cells isolated only thirty-four grew and none of them was found to oxidize the ammonium salt. This work shows, however, that non-oxidizing forms not only persist in the enrichments but that it is possible for them to develop from single cells in a mineral solution. It was clear that the enrichments must be improved, *i.e.,* the proportion of nitrifiers to other forms increased, if the method was to be successful. If some chemical could be found which is not toxic to the nitrifiers and which at the same time would materially retard the growth of other soil forms in the cultures, a satisfactory enrichment for isolations would be secured. Some of the dyes were tried for this purpose on the *Nitrosomonas* group but they were found to be more toxic to the nitrifier than to the contaminating forms in the cultures. Other chemicals were tried but without success. Finally copper carbonate when used with an equal amount of calcium carbonate was found to reduce the numbers of organisms which develop on a nutrient agar plate (nitrifiers do not develop on this medium) while it did not stop the oxidation. From enrichments prepared with this compound only some twenty cells were picked before a culture was secured which would oxidize the ammonium salt as rapidly as the enrichment from which it was isolated.

Fifty-six cells were isolated from the first pure culture, and of these two developed and oxidized the ammonium salt as rapidly as the mother culture.

In the case of the *Nitrobacter* group (those which oxidize the nitrites to nitrates) it was found recently by Prouty[2] that they could tolerate certain dyes. This treatment ought to reduce the numbers of contaminating forms in the cultures but there are as yet insufficient data on the subject. Enrichments were prepared in the usual way, that is, by transferring to fresh sterile medium when all the nitrites had disappeared from the cultures. After the fourth transfer since starting with soil, the cultures were exposed to a 1 per cent. solution of rosanaline hydrochloride for ten minutes, inoculated into fresh sterile medium and set aside for ten to fifteen days. From such a culture 101 cells were picked, of which fifteen grew and thirteen oxidized the nitrites as rapidly as the enrichment from which they had been isolated. Here it should be noted that two cells developed in the mineral solution which would not oxidize the nitrite. This is further evidence that non-oxidizing forms readily develop in the cultures. An average of twenty-two cells were isolated per day, but this does not include the time required for making media and preparing the apparatus for isolations.

[1] This work was made possible by the National Research Council and carried out in the laboratories of agricultural bacteriology, University of Wisconsin. The author is indebted to Dr. E. B. Fred for helpful suggestions and criticisms during the course of the work.

[2] Chas. C. Prouty, "The Use of Dyes in the Isolation of a Nitrite-oxidizing Organism," *Soil Sci.*, 28: 125–136, 1929.

Reisolations by picking cells from one of the pure cultures were made. Twenty cells were isolated and ten of them grew and oxidized the nitrites. If the percentage of cells which grow is the same in the isolations from crude cultures as from pure cultures it would indicate that only 30 per cent. of the cells in the enrichments were nitrite-oxidizers. The results are very satisfactory since it required only a few days to secure these cultures.

From this brief discussion it is seen that it is possible to secure pure cultures directly from enrichments by isolating single organisms; and when all the factors are considered, this method is more satisfactory for the nitrifiers than the plate method which does not usually yield pure cultures and which requires a great deal of time for carrying out.

Details of the method used and descriptions of the organisms isolated will soon be published.

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THE BORON CONTENT OF ORANGES

In connection with a study of the relation between the boron content of irrigation water and a certain type of injury to citrus and walnut trees in southern California, it has been observed that these plants take up substantial quantities of boron which is deposited in the leaves. This fact has made it possible to diagnose cases of boron injury. Boron occurs as a natural constituent of practically all irrigation waters in southern California. In most of these waters the content of elemental boron ranges from .15 to .3 parts per million, while in those supplies that have caused trouble the boron content may range up to 2.5 parts per million. Orange trees irrigated with low-boron water have in their mature leaves from 50 to 150 parts per million of boron, based on the dry weight of the leaves. Those irrigated with high-boron water may show from 600 to 1,000 parts per million of boron to the dry weight of the leaves.

A very few analyses of fruits and of twigs or chlorophyll-bearing branches, chiefly of lemons, have indicated that most of the boron taken up by these trees is deposited in the leaves, but it has seemed worth while to ascertain whether or not there are appreciable differences in the boron content of the fruits produced by trees having pronounced differences in the boron content of their leaves. For this purpose a number of analyses have been made of fruits of navel orange trees grown under different conditions with respect to the boron content of the irrigation water and known to have very different proportions of boron in the leaves. In view of the fact that the skin of the orange is green when the fruit is young, it seemed desirable to make separate analyses of the skin and the pulp.

The fruits to be analyzed were picked from the trees in the early part of March, 1929, when they were fully mature. At the same time samples of mature leaves were picked from the same trees. The boron content of the irrigation water used in each grove had been determined previously by analyzing a series of samples taken at different times. In preparing the fruits for analysis the skins were removed and the pulp was dried in the presence of sodium and calcium hydroxides to prevent the loss of any boron by volatilization. The peel was dried without treatment. When the fruit material was thoroughly dry it was ground to a fine meal and the boron content was determined by the Chapin method, as modified and developed by Wilcox in the Limoneira Laboratory. The leaves were analyzed by the same method.

The essential results of these analyses are given in the accompanying table. Samples 1 and 2 were obtained from the vicinity of Riverside, California, where the boron content of the irrigation water is low. Samples 3 and 4 were obtained in the Santa Clara Valley where some of the irrigation waters have a high boron content. The boron content of the

The Boron Content of Irrigation Water and of the Leaves and Fruit of Navel Oranges Irrigated with the Water

	No. 1	No. 2	No. 3	No. 4
Irrigation water, boron, parts per million	.20	.35	1.25	2.45
Leaves, boron, parts per million	35	90	515	854
Ave. fresh wt. per fruit, grams:				
Pulp	133.2	95.6	119.3	141.7
Peel	61.9	44.0	69.6	61.3
Ave. dry wt. per fruit, grams:				
Pulp	17.0	13.6	13.6	15.3
Peel	14.8	12.0	15.0	12.5
Boron content, parts per million:				
Dry pulp	10	11	22	38
Dry peel	21	22	40	44
Boron content per fruit, mgs:				
Pulp	0.17	0.15	0.30	0.58
Peel	0.31	0.26	0.60	0.55
Whole fruit	0.48	0.41	0.90	1.13
As boric acid, per fruit, mgs:				
Pulp	0.97	0.86	1.71	3.31
Peel	1.77	1.48	3.43	3.14
Whole fruit	2.74	2.34	5.14	6.45

irrigation water is given in the table in parts per million, while for the leaves and fruits the boron is reported in parts per million of the dry weight of the material, and also it is expressed in terms of milligrams of boron in each fruit and as the equivalent of boric acid (H_3BO_3) in the individual fruit and in the peel and pulp of the individual fruit.

These results show that there is a direct relation between the boron content of the irrigation water and that of the leaves, and that the same relationship holds with respect to the fruit, both for the peel and pulp.

The proportion of boron to dry weight is much lower in the fruit than in the leaves and the differences are much less. But it seems clear that not all the boron taken up by the orange tree from the soil solution is deposited in the leaves.

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THE NATIONAL ACADEMY OF SCIENCES. II

The band spectrum of ozone in the visible and photographic infra-red: OLIVER R. WULF (introduced by C. G. Abbot). Photographs of the spectrum of ozone have been taken over the range 10,000 Å to 4,000 Å, using a 33-meter absorption path and ozone-oxygen mixtures of low ozone concentration at one atmosphere pressure. The visible bands exhibit regularities but are diffuse and show no tendency to form heads. In the infra-red a new series of weak bands has been found.

Significance of recent cosmic ray experiments: R. A. MILLIKAN and I. S. BOWEN. The experiments reviewed are (1) those of Millikan on the influence of nuclear mass on the absorption coefficients of cosmic rays; (2) those of Millikan, Bowen and Chao on the absorption coefficient of monochromatic Th C″ rays; (3) those of Regener and of Millikan and Cameron on the absorption coefficient of cosmic rays at great depths in water; (4) those of Millikan and Cameron on the absorption coefficients of cosmic rays at great altitudes, and (5) those of Bothe and Kolhörster on the absorption coefficients of the beta rays accompanying cosmic rays. There have been but three possible ways suggested for accounting for the foregoing results. The enormous energies demanded by them are obtained (1) from cosmic electrical fields, (2) from the annihilation of matter, (3) from the building up of the heavy elements out of the light. The requirements of each of these theories are discussed and experiments suggested to decide between them.

Prediction of trans-Neptunian planets from the perturbations of Uranus: E. W. BROWN. The prediction of the place of a trans-Neptunian planet by Percival Lowell is shown to be due mainly to a mathematical relation which depends on the number of years during which the planet Uranus has been observed. This fact is brought out by a new analysis of the work of Lowell published in 1915. It is shown that this relation has the effect of giving a prediction of the place of an unknown planet whether the planet has any real existence or not. If the same methods had been used with the additional observations of Uranus which have been made since Lowell completed his work, the predicted place in the sky would have been changed by some twenty-five or thirty degrees. In calculating the disturbance of the motion of one planet by another, the astronomer has to use a measuring rod, the shape, size and position of which can be changed to fit the observations. The reason for this is that he does not know the exact shape, size or position of the orbit of the disturbed planet until he has obtained them from the observations. If the planet has been observed for a long time, the discovery of a new body which alters its motion will affect the measuring rod very little. But if the period of observation covers less than two revolutions of the planet round the sun, it may alter it considerably. Uranus had been continuously observed up to the time Lowell completed his work for about 130 years. In this interval it made only one and a half revolutions round the sun. Consequently, the measuring rod could be so adjusted that the apparent effect of an exterior planet during that time is very small, although the planet may be quite large. A small planet will produce little effect in any case. Thus small deviations of Uranus during that time may mean the existence of an exterior planet or no such planet at all. If we assume that a large planet exists it is shown, without any further use of the observations, that it will be predicted as nearest to or furthest away from Uranus in the middle of the interval, that is, about 1848. The same assumption gives a prediction that the planet will be nearest to or farthest away from the sun near the same date. These are almost exactly the dates found by Lowell and they give the chief factors in the predicted place. The result would be the same, however small the mass. Hence, it gives no indication as to whether the planet exists. The rest of Lowell's prediction depends on a few unreliable observations which were found in astronomical records made before it was known that Uranus was a planet and not a star. We already know that the planet is too small to satisfy these early observations, whether they are good or bad. It follows that the discovery of a new planet near the predicted position must be regarded as accidental, or perhaps as the first of others to be found beyond the orbit of Neptune. Although it seems impossible to give Lowell the credit of having predicted a new planet, his work undoubtedly stimulated a search for one. The value of a scientific hypothesis is not to be judged by its truth but by the impulse which it gives to the search for truth.

Note on the preceding paper: D. BROUWER (introduced by Ernest W. Brown).

Relative value of physiographic and paleontologic criteria in Pleistocene correlations: Frank Leverett. The physiographic criteria embrace certain persistent and practically uniform conditions, such as rainfall, stream gradient and character of formation, which produce a given result in the modification of a land surface in a given time. Thus each glacial formation of the several which are present in glaciated districts shows a degree of erosion and weathering consistent with its age. So also do the Pleistocene marine terraces of the Atlantic and Gulf coastal plains. It is evident to a person who has studied both the glacial and the marine terraces that the Pensacola marine terrace which has a shore line in Florida at about 33 to 35 feet is no older than the late Wisconsin drift, but the higher marine terraces, Tsala Apopka and Newberry, are evidently of greater age than the Wisconsin drift. Turning now to the paleontologic criteria, it appears that the remains of many species of extinct vertebrates are found on the Pensacola terrace, some of them in close association with remains of man. From studies elsewhere it had been inferred that certain species had become extinct as early as Middle Pleistocene time. On this basis the terrace would be given a much greater age than is consistent with its freshness of contour, and the human remains if contemporary with those of the extinct animals would be given very great antiquity. This naturally raises the question of the value of paleontologic criteria in comparison with physiographic criteria. It is evident that the extinction of a species of either animal or plant life is due to factors of uncertain and varying character, which can not be predicted and which do not of necessity have time limitations. A given species may suffer extinction in one district long before it does in some other district in which conditions are more favorable for its continuation. The physiographic criteria may thus be made a basis for correlations where paleontologic evidence is of conflicting character. The physiographic criteria can be depended upon, however, only as a measure of age of relatively young formations. In older formations than the Pleistocene the paleontologic criteria are likely to be preferable to the physiographic. Neither set of criteria has the definiteness in determination of the age of an old formation that is possible in the determination of the age of a Pleistocene formation.

Some new fossils from the Middle Cambrian Burgess shale of British Columbia: Rudolf Ruedemann. The Middle Cambrian Burgess shale of British Columbia afforded, some twenty years ago, to Dr. C. D. Walcott the richest and most varied Cambrian fossil association yet discovered. It consists of seaweeds, sponges, cystids, holothurians, medusae, annelids, crustaceans and merostomes. The material is preserved in a fine-grained shale to the finest details, as the intestinal canal and the hepatic caeca of the crustaceans, and its continued study is expected to throw a flood of light on the phylogeny of various classes of invertebrates. A hitherto unstudied portion of this collection, considered as probably consisting of graptolites, was turned over to the writer and furnished some most interesting additions to the Burgess shale flora and fauna. A fossil similar to the graptolite Dictyonema proved a seaweed with a reticulate system of strengthening ribs of the thallus, which alone remain on maceration. Another fossil is a hydrozoan, belonging to the Hydroid Coelenterata, with distinct thecae. A small, black, leaf-like fossil was found to be a cystid of such primitive structure that it may be near the roots of the phylum of echinoderms. A fossil looking like a well-known branching graptolite is instead a crustacean with enormously developed many-branched swimming limbs, that in appearance is an overgrown nauplius of the present crustaceans, thereby indicating its ancestral character. Finally the fossil Marrella that was considered a bizarre crustacean with two pairs of gigantic horn-like appendages of the carapace was recognized as a freshly moulted trilobite neolenus. Its dorsal tests are still so thin that the delicate structure of the underside of the body is visible. These finds indicate that treasures are still buried in the ancient Burgess shale.

Bearing of Titanothere researches on the principles of mechanical evolution (to be printed in Science): Henry Fairfield Osborn.

The third dimension in Yellowstone Park (illustrated): Arthur L. Day.

Iron-bacteria in silicified bog-iron deposits of Cambro-Ordovician age: David White. Specimens of silicified limonite from the Jonesboro formation, of Cambro-Ordovician age, in Virginia, are found, when examined by means of thin sections under the microscope, to be petrified bog ore deposits in which several kinds of bacteria and algae are present in rather remarkable preservation. Among the plants, which appear golden yellow in the section, are forms closely resembling bog-iron depositing bacteria of the present day, such as *Siderocapsa* and *Crenothrix*, together with a representative of a low order of algae. The petrographic character of the deposit, which presents some notable crystallographic features, has been described by Dr. M. I. Goldman.

The peptide linkage in proteins: Wilder D. Bancroft. The simplest way in which two amino-acids can condense gives the group —CONH—, which is known as the peptide linkage. Emil Fischer assumed that this was the most important linkage in the proteins and did an immense amount of work in synthesizing polypeptides. We have found that a solid containing the peptide linkage will apparently always add hydrogen chloride gas stoichiometrically to form the group —CONH(HCl)—. We have also found that hydrogen chloride gas is not taken up stoichiometrically by any of the nitrogens in zein, from which it appears to follow that there are no peptide linkages in zein. If there are no peptide linkages in zein, it becomes an interesting question as to what percentage of peptide linkages there may be in other proteins such as edestin and gliadin. The first question to tackle is, of course, what the nitrogen linkages are in zein.

The structure of some sodium and calcium aluminosilicates: LINUS PAULING (introduced by A. A. Noyes). With the use of the set of structural principles recently developed, the structures of the minerals natrolite, $Na_2Al_2Si_3O_{10} \cdot 2H_2O$, the scapolites (of which the end members are marialite, $Na_4Al_3Si_9O_{24}Cl$, and meionite, $Ca_4Al_6Si_6O_{24}(SO_4, CO_3)$), and davynite-cancrinite, $(Na, Ca)_4Al_3Si_3O_{12}(CO_3, SO_4, Cl)$, have been determined. In each case the crystals consist of a framework of AlO_4 and SiO_4 tetrahedra joined by the sharing of oxygen ions at tetrahedron corners. Within the framework there are cavities which are occupied by sodium or calcium ions, large negative ions and water molecules or other groups, which can be removed or replaced by other ions or molecules without destroying the framework. The structures account for the characteristic phenomena of base exchange and of dehydration and rehydration (of zeolites) shown by the substances.

Synthesis of d-mannoketoheptose: C. S. HUDSON and EDNA M. MONTGOMERY.

Isolation of four forms of d-mannoheptose: C. S. HUDSON and EDNA M. MONTGOMERY.

Interaction of nitrogen trichloride and nitric oxide at -150°; further evidence for the formation of nitrogen dichloride and of mono-oxygen-di-nitrogen-dichloride: WILLIAM ALBERT NOYES. In a paper published two years ago it was shown that at -80° two mols of nitric oxide react with one mol of nitrogen trichloride, giving one mol of nitrosyl chloride, one of nitrous oxide and one atom of chlorine. This was explained by assuming that the primary reaction gives nitrosyl chloride and nitrogen dichloride and that the latter immediately combines with nitric oxide to give mono-oxygen-di-nitrogen-dichloride, $ON—NCl_2$. The reaction has now been carried out at -150°, the boiling-point of nitric oxide. At this temperature, three mols of nitric oxide react with the trichloride, giving two mols of nitrosyl chloride, one of nitrous oxide and one atom of chlorine. The simplest explanation of this result seems to be that the mono-oxygen-di-nitrogen-dichloride is sufficiently stable at -150° to permit a third mol of nitric oxide to take from it one atom of chlorine. Either at that temperature or on warming up, the mono-oxygen-di-nitrogen-monochloride decomposes to nitrous oxide and chlorine.

Diazocamphene from bornylamine and from neo-bornylamine: WILLIAM ALBERT NOYES and ULRICH HEUBAUM. Forster and others have shown that two bornyl amines are formed by the reduction of camphor oxime, normal bornyl amine and neo-bornylamine. These are optical isomers, because of the asymmetry of the carbon atom to which the amino group is attached. From these amines the two urethanes and their nitroso derivatives have been prepared. By the action of sodium methylate on the nitroso derivatives of the urethanes, at a low temperature, the corresponding diazo compounds have been made. These compounds are even more unstable than the diazo compounds prepared by Kendall and Noyes. Their specific rotation and rotary dispersion were determined, approximately, however. They have a high rotation and an extraordinary rotary dispersion, with a maximum in the green, similar to those obtained by Kendall for the diazo compounds from the amino-camphonanic acids. It has not been possible to show a difference in the specific rotations of the two compounds, probably because of the difficulty of exact measurements with such unstable, colored compounds. Mr. Ray, of Grinnell, has, however, shown that the two diazo compounds prepared by Kendall give different decomposition products, demonstrating that the carbon atom combined with the diazo group is asymmetric.

The effect of low temperatures on the sensitivity of radiometers: SINCLAIR SMITH (introduced by George E. Hale). The sensitivity of a radiometer at the temperature of liquid air was compared with that of the same radiometer at room temperature. Curves were derived for both temperatures which show the change in sensitivity with pressure for the same radiometer in hydrogen, helium and air. In these gases, at the lower temperature the maximum sensitivity is increased and shifted towards lower pressures. The form of the pressure-sensitivity curve remains unchanged.

The crystal clock: W. A. MARRISON (introduced by F. B. JEWETT). A quartz crystal may be used as the rate controlling element in an accurate clock. From the standpoint of stability, crystalline quartz has some inherent advantages over all other materials for this use. A clock system based on a short period vibration such as is obtained from a quartz crystal oscillator has many advantages over conventional systems for making time comparisons. These include means for intercomparing separate systems, means for measuring short time intervals accurately and means for producing time signals electrically as accurately as the absolute time can be determined. The dial setting and the rate of a crystal clock may be changed by continuous adjustments without in any other way affecting the time-keeping qualities of the system. The rate of the crystal is not affected by magnetic fields or changes in g, and to only a small extent by earth vibrations. Clocks may be operated at different rates from the same rate controlling element. In particular a mean solar clock and a sidereal clock can be operated from a single crystal and rated so that the error in the ratio of the rates is less than one second in a century. Accurate mean solar and sidereal seconds timing pulses may be obtained electrically from the respective mechanisms.

Analysis of the growth curve of man: FRANZ BOAS. Our knowledge of growth is based essentially upon measurements of groups of children of varying ages. The following observations are based on the study of individual growth curves. The acceleration of rate of growth of boys during adolescence occurs at varying times, between eleven and seventeen years. Boys who show the

most rapid rate of growth at an early time pass through the whole developmental period with greatest rapidity. They have a higher rate of growth at this period than any other group, and their total increase during a period beginning three years before and ending three years after the period of most rapid growth is greatest. The material available at the present time does not show any appreciable influence of the difference in period of most rapid growth upon the average stature of the adults. Even those who have their maximum rate of growth at the same time vary in the extent of the growth period; among some it closes soon after the period of maximum rate of growth; among others it extends over several years. It is probably due to this fact that the variability of stature of slowly maturing groups of boys is greatest. The increase of variability, which is characteristic of growing boys taken *en masse,* disappears for the group whose maximum rate of growth is between thirteen and fourteen years. For all the others the increase of variability is much reduced. The data available at the present time also suggest that adults who have developed slowly are more variable than adults who have developed rapidly. This may be an expression of a more intensive influence of environmental conditions favoring or inhibiting growth.

An archeological research and its ramifications: A. V. KIDDER and S. G. MORLEY (introduced by John C. Merriam). In order to interpret in terms of history the archeological data emanating from investigations by Carnegie Institution of Washington in the Maya field, it is necessary to call upon botanists, zoologists, geologists and meteorologists for information regarding environmental factors, and upon medical men and physical anthropologists for information as to biological aspects of man. Cooperations have been established with workers in certain of the above sciences and enlistment of aid from others is contemplated. Work accomplished to date reveals problems of special interest to individual sciences and of general significance to larger groups. The interrelation of the studies is considered, and it is pointed out that coordinated effort not only is necessary for solving the complex questions of human history but also serves as a practical method of forming contacts between diverse branches of natural science.

Concentration of remnants of Indian tribes in northwestern California: C. HART MERRIAM. Probably no part of the United States is so little known from the standpoint of its aboriginal inhabitants as a small area in the mountains of northwestern California—an area restricted to the drainage basins of the Salmon and New Rivers with adjacent parts of the main Trinity and its South Fork. Within a radius of forty miles from Hoopa Valley there were in whole or in part the home lands of nineteen tribes of Indians, representing eight linguistic stocks. It is doubtful if in any other part of the world there are in so small an area so many tribes speaking different languages. Most of these tribes are fairly well known, but during the mining days of the fifties and early sixties several of them were practically exterminated by the onrush of gold seekers and the troops called in to help. Indeed, so complete was the destruction that in the case of four of the tribes the few survivors succeeded so well in remaining hidden from inquisitive eyes that not even the names of the tribes were ascertained by anthropologists.

A remarkable case of word borrowing among California Indians: C. HART MERRIAM. Work among the Shoshonean tribes on both sides of the Nevada-California boundary south of the latitude of Mono Lake has brought to light a surprising if not unique case of the borrowing of words, particularly the names of animals. These names as used by the Monache of Owens Valley, on the east side of the Sierra, disagree almost wholly with the names used by their relatives only a short distance farther north—the "Northern Piute" bands of Mono, Walker and Pyramid Lakes. Further study has shown that the un-Shoshonean names of the Owens Valley Monache are in current use among the several derivative Monache tribes on the west side of the Sierra. These names, that differ from those of the "Northern Piute," agree essentially with those of an unrelated stock, namely, the Yokut, of San Joaquin Valley. In other words, a series of tribes of Shoshonean stock have set aside the animal names in common use among their near relatives and have replaced them by the names used by several tribes of a widely different linguistic stock—the Yokut. So far as I am aware, no parallel is known.

The theory of specific skills in musical training: C. E. SEASHORE. The theory that success in musical performance, either vocal or instrumental, is conditioned upon the early mastery of a few fundamental skills was advanced. Methods of developing these skills by instrumental aids in intensive training were illustrated and the instruments needed for such training were shown. Among these were the rhythm meter, the tone dynamometer, the tonoscope, the projectoscope and the piano camera, all instruments designed and built in the psychological laboratory of the University of Iowa.

BOOKS RECEIVED

BEERY, PAULINE G. *Stuff: The Story of Materials in the Service of Man.* Pp. xiii + 504. Illustrated. Appleton. $5.00.

CLARK, AUSTIN H. *The New Evolution: Zoogenesis.* Pp. xiv + 297. Illustrated. Williams and Wilkins. $3.00.

GARRETT, HENRY E. *Great Experiments in Psychology.* Pp. xvii + 337. 11 plates. 35 figures. Century.

JASTROW, JOSEPH. *Piloting Your Life.* Pp. xvi + 372. Greenberg. $3.50.

PARSONS, T. R. *The Materials of Life:* A General Presentation of Biochemistry. Pp. 288. 8 illustrations. Norton. $3.00.

SCOTT, GEORGE G. *The Science of Biology:* An Introductory Study. (Revised edition.) Pp. xx + 633. 390 figures. Thomas Y. Crowell. $3.75.

WORSNOP, B. L. *X-Rays.* Pp. ix + 101. 36 figures. Dutton. $1.10.

YOUNG, JOHN W. *Projective Geometry.* The Carus Monograph Series. No. 4. Pp. ix + 185. 65 figures. Open Court.